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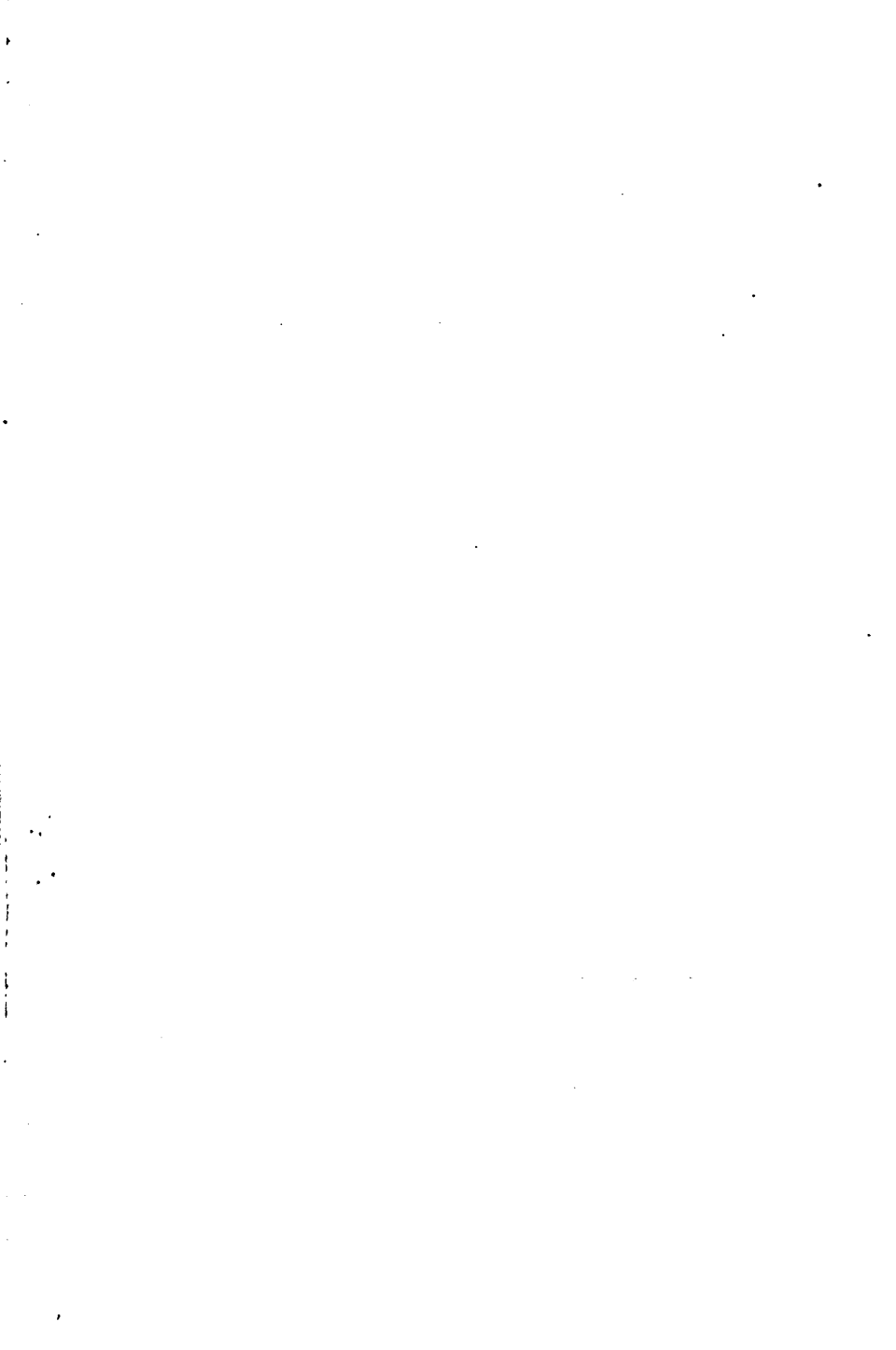
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**LESSONS IN
HYGIENIC PHYSIOLOGY**

•The  Co. •

LESSONS IN HYGIENIC PHYSIOLOGY

BY

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“SOCRATIC LESSONS IN SCIENCE FOR TEACHERS”

“A HEALTH PRIMER,” ETC.

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TO THE TEACHER

For convenience in examining this book, it may be well to insert a few page references, as the book is, in some respects, radically different from the usual school physiology. The book aims to teach the science and art of preserving health; the teaching is based largely on observational studies of the body, experiments, and study of the charts and figures which it contains. Observational study is carried out by frequent single questions and by more lengthy exercises (pp. 35, 86, 107, etc.). The experiments illustrate some point in physiology (pp. 14, 21, 25, etc.); they are not merely copied from texts on physics and chemistry, as is usual in those physiologies which are not wanting altogether in experimental work. To aid in founding the study upon facts and not mere words, the author has devoted a great deal of time to the illustrations. Books of this size usually have sixty or seventy figures; this book contains about three times as many, or one hundred and ninety-eight in all, sixteen of which are colored. Care has been observed to make use of only the best sources, and many figures are drawings of specimens hardened by the new formalin method (Figs. 21, 62, 68, 133, etc.). The author has made use of color (Plates IX to XIII), for it has long seemed strange to him that in the geographies Maine is purple, Vermont red, and New Hampshire blue (when they are really none of these, but are green, brown, and white by turns), yet expense must be spared in the physiologies, and no hint given of the natural tints of the bodily organs. When physiology comes into its rights, the same care will be used in teaching the human body as in teaching the political divisions of Africa and Australia. There is a saying among teachers that there is no impression without expression. For testing the accuracy of what has been learned, review questions are abundant. However, mere reproduction of facts

learned is the crudest form of expression. The best test as to whether a pupil has mastered a subject is not the ability to tell something about it, but the ability to do something with it, to make use of it. For using the knowledge acquired, provision is made in two series of exercises, containing in all about four hundred questions. The questions of the first series (Thought Questions, pp. 13, 15, 24, etc.) furnish exercise in reasoning from different points of view upon the anatomy and physiology already learned; those of the second series (Practical Questions, pp. 51, 69, etc.) test the ability of the pupil to apply to particular cases the laws of hygiene stated in the text. The exercises in composition writing are designed to give scope to the pupil's originality.

This study, more than manual training, bookkeeping, domestic science, or any other subject, may be made a training for practical life. Paul Bert, in a preface to a school book, says that he "has shunned the temptation of trying to present practical applications of the principles laid down, since they are certain not to be fully comprehended by the average pupil." The author begs to suggest that if the pupil must never apply the knowledge gained for fear of using it in a wrong way, the instruction must be worthless; that not to pass from pure to applied science until able to do so without error, is as vain as not to go into the water until one has learned to swim. It is doubtless true, however, that a higher order of teaching is required to teach a practical subject than a purely theoretical one. Many teachers have taught history to boys, yet could not teach them anything about cigarettes or drawing.

To the teacher who is using this book a few statements may prove suggestive. In the first place it should be understood that criticisms will be highly appreciated. Any suggestions from fellow-teachers for making the book more practical and serviceable will be carefully considered by the author. When we remember that natural science has been taught to youths for only fifty years, while mathematics and language have been taught for centuries, it is not strange that methods in science teaching are still in a rudimentary stage. This book is an humble effort to hasten the time when natural science shall be

taught with the same thoroughness and thoughtfulness as language and mathematics. We would smile at a grammar or an arithmetic which had every exercise worked out, every conclusion stated, every problem explained, and which left nothing for the pupil to do but to absorb the statements given. Yet this is exactly the plan upon which physiologies are written. The school text-books written by physicians and filled with technical facts, the flood of hastily prepared temperance books, and the recent diluted physiologies which make the science easy by omitting most of it, all agree in one thing, — the pupil must be given no chance to think. It is suggested that a whole lesson be devoted to each of the longer exercises, just as a set of examples in arithmetic constitutes a whole lesson. By thinking out every one of the four hundred problems, the pupil will form the habit of reasoning.

This book is an attempt to simplify physiology without weakening the presentation of its three essential principles. These are the biological principle of environment, the chemical principle of oxidation, and the physical principle of energy. The teacher will find it profitable to emphasize them wherever they occur in the text. The steps in physiology are as interdependent as the steps in geometry, and must be thoroughly connected in order to be understood. To review each chapter as soon as finished is not to take a new view; to review a chapter after several have been studied is to connect them in one view and grasp them all more thoroughly. Hence the review questions have been arranged on this plan. The various exercises also provide constant review. The review by the competitive method, an example of which is given at the end of the chapter on The Skin, takes into account youthful love of contest and excitement; it is hoped that the teacher will have such a review on each subject. To encourage the pupil in associating his ideas, a voluntary review should frequently be held. This is sometimes called a "Quaker meeting review," because each pupil speaks only when he feels inclined. The teacher merely names a chapter, and calls in rotation the names of the pupils who, by raising their hands, signify a willingness to tell something about this chapter.

The subject is approached throughout from the standpoint of health, as not only the most useful, but also the most interesting point of view. The temperance instruction is conservative, but full, not only that the laws of the several states may be complied with, but because of its utility and vital interest. If not unduly dwelt upon, this is one of the most interesting subjects to pupils. They have seen the effects of intemperance on all sides, often indeed among their own families and friends, and they have a keen interest in learning what science has to say on the subject. Prejudice has warped judgment on both sides of this question, especially among the opponents of total abstinence. If science shows that alcohol retards digestion, they say that this prevents hunger and is a good thing, as if dyspepsia were a blessing. When willing to admit the effects of alcohol upon youth, they say that young men may begin drinking at twenty-one, as if a change came over the nature of the cells at that age. The fight for error against truth is strong, for the error is upheld by antiquated notions, a love of indulgence, and a business that yields two billions of dollars a year.

The author has taken pains to warn people against meddling with their bodies, against credulous belief in the health frauds that abound on all sides, and has striven to instill a love of natural instincts and a love for natural living. Hence the treatment of the sympathetic nervous system and of general sensation has been carefully simplified and made unusually full.

Acknowledgment is made of the use of engravings from Jegi's, Peabody's, and Huxley's "Physiologies" and Cunningham's "Anatomy."

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LESSONS IN HYGIENIC PHYSIOLOGY

CHAPTER I

INTRODUCTION

PERHAPS you have studied Physiology and Hygiene before, and if you were asked how does the body grow, you could readily answer. You would say, "The food nourishes the body and enables it to grow." But if you were asked *how does the food enable the body to grow*, you could not answer. If you were asked how a cut in the skin is healed, you would say that the blood brings the nourishment to the skin; but you have, as yet, no idea as to *how the skin uses this nourishment to heal the cut*.

If you were asked how is it that the body is always warm, even on the coldest winter day, you would say that the oxygen, so abundant in pure air, is taken into the body through the lungs, and burns the food. But where is the fire? Is it in the blood, or in the muscles? What regulates the burning? What regulates the use of the food after it has been digested, and of the oxygen after the lungs have furnished it to the blood? In order that you may better understand these things, you will now study physiology from a new point of view. *You must study something of the tissues of the body and how these tissues live and grow.* But let us not forget for a moment that there are many mysteries about life that man never has solved and never

will solve. To help us to understand more about man's body, we will first compare man with other animals.

Which is more like a Man, a Crawfish or a Bird? — You reply, "A bird is more like a man." But *why* do you say so, although a bird has wings? You answer, "Because the bones and blood of a bird are more like those of a man than are such parts of a crawfish."

Which is more like a Man, a Bird or a Beast — for example, a horse? You say the horse is more like a man. A horse has *hair*; a bird has none. A bird *lays eggs*; a horse does not. A horse has *teeth*; a bird has none.

Which is more like a Man, a Horse or a Dog? — You are not so quick in replying this time. A dog and a horse are about equally intelligent, both have four legs and no hands; but by close examination you see that the *teeth* of one are more like a man's teeth than are those of the other; that a dog has *claws* on his feet, and a horse has *nails*, although, indeed, the latter has only one toenail on each foot — a very large one called a hoof. But whether you think a dog or a horse is more like a man, you know that they are both more like a man than is a bird or a crawfish.

There are other animals that are even less like ourselves than those which have been mentioned. There are the *insects*, or animals with six legs and the body in three parts, like the wasp, the ant, the grasshopper. There are the *earthworms* with no legs at all, the oysters and clams, the starfish, the sponges, the small coral animals.

But of all the animal kingdom, the animals that are most different from man are the *minute creatures that can be seen only with a microscope*. They are so small that it takes thousands of them to make a mass as large as the head of a pin. In fact, some of the pupils may ask, "Are

such creatures animals at all?" Certainly, for they are neither vegetables nor minerals.

The Ameba. — One of the most interesting of these microscopic animals, and one that is very easy to find with the aid of a microscope, is the *a-me'-ba* (Fig. 1; spelled

also *amæba*). We have only to place some dead grass in a vessel of water, and let it stand for a few days, when, if we look

through a microscope, FIG. 1. — AN AMEBA, highly magnified.

nu, nucleus; *psd*, false foot.

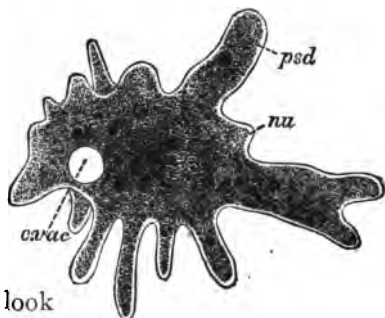
we shall be likely to find amebas in a drop

of the water. *A thousand of them placed in a row would hardly reach an inch.* Some may doubt whether the ameba is a complete animal. Study the figures of it, and you can find no head, or arms, or legs, or mouth. It appears, when still, to be merely *a lump of jelly*. But the ameba can *push out any part of its body as a foot*, and move slowly by rolling its body into the foot. *It can put out any part of its body as an arm*, and take in a speck of food; or, if the food happens to be near, the ameba can *make a mouth by drawing in any part of its body*, and then swallow the food by closing around it. See the pictures (Fig. 2). The ameba has no

lungs, but *breathes with all the surface of its body*. Any part of its body can do anything that another part can do.



FIG. 2. — THE AMEBA taking food.



When the ameba grows to a certain size, it multiplies by squeezing together near the middle (see Fig. 3) and *dividing into two parts.*



FIG. 3. — A CELL dividing into two cells.

The Ameba and Man Compared. — The microscope shows us that the skin, the muscles, the blood, — in fact, *all parts of the body,* — *contain numberless small parts called cells.* These cells are continually changing with the activities of the body. One of the most interesting kinds of cells we shall find to be the *white blood cells*, or corpuscles. One is shown in Figure 4, with the changes that it had undergone at intervals of one minute. The thought will readily occur to you that *these cells, although part of man's body, resemble the ameba* that lives an independent life. The cells in the body have some resemblance to the one-celled animals, of which the ameba, that has been described, is a type. You will now begin to see what is meant by the statement that a man or a horse or a fish — in fact, any large animal —

has something of the nature of a colony, or collection, of one-celled animals. You are now prepared to understand a little as to how the body grows, and how a cut in the skin is repaired. *The cells take the nourishment brought by the blood,*

use it, and grow and multiply like the ameba. Thus new tissue is formed. All animals and vegetables — that is to say, all living things — are made of cells.



FIG. 4. — A WHITE BLOOD CELL, magnified; forms noticed at intervals of one minute.

A living cell *always* contains a still smaller body, called a **nucleus** (Fig. 5). There is sometimes a small dot in the nucleus called the *nucleolus*. The main body of the cell consists of a living substance called **protoplasm**. Usually, but not always, there is a wall surrounding the cell, called the *cell wall*. Workers with the microscope found long ago that animals and plants are constructed of little chambers which they called cells. It was found later that the soft contents in the little chambers is of more importance than the walls which the protoplasm builds around itself. A living cell is not like a cell in a honeycomb or a prison. In the study of animals and plants *we define a cell as a bit of protoplasm containing a nucleus*.

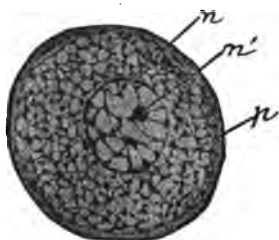


FIG. 5.—DIAGRAM OF A CELL.

p, protoplasm (complex in structure); *n*, nucleus; *n'*, nucleolus.

A *fiber* is threadlike, and is either a slender cell (Fig. 6), a slender row of cells (Fig. 9), or a branch of a cell. A **tissue** is defined as *a network of fibers or a mass of similar*



FIG. 6.—A CELL so slender that it is called a *fiber*.

n, nucleus (from involuntary muscle around intestine).

cells serving the same purpose, or doing the same work. A *membrane* is a thin, skinlike tissue (Fig. 7).

A New Insight into the Nature of the Human Body.—

The human body is *a community of cells*, and may be compared to a community of people. It is a crowded community, for all the citizens live side by side as they work. They are so small that it takes several hundred of them to make a line an inch long. We should never have sus-

pected the existence of cells had it not been for the microscope; but now we know that they eat and breathe and work and divide into young cells which take the place of the old ones.

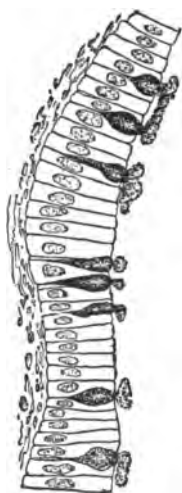


FIG. 7. — MUCOUS MEMBRANE formed of one layer of cells. A few cells secrete mucus.

A child that is born in a **community of people** may become a railroad man and carry food and other freight from place to place; so in the great **community of cells** (see Fig. 8) making up the human body, *the red blood cells, like the railroad man*, are employed in carrying material from place to place. But the community is old-fashioned, for the citizens build canals instead of railroads for their commerce (see Fig. 84). Just as a child may grow up to be a *farmer* and aid in the conversion of crude soil into things suitable for the use of man, so *the digestive cells* take the food we eat and change it into material with which the cells can build tissue (see Fig. 7). Some of the citizens of a community must, at times, take *the part of soldiers* and policemen, and protect the community against the attack of enemies; we even find in the community of cells those which have this duty. *The white blood cells*, already referred to, may be called the soldiers; for they

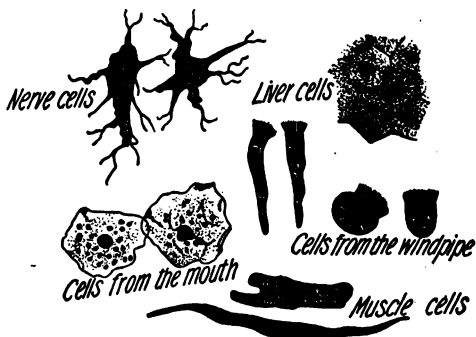


FIG. 8. — VARIOUS CELLS of the body. (Jegi.)
Tiny citizens of the bodily community.

go to any part attacked by injurious germs, a speck of poison, or other enemy, and try to destroy the enemies by devouring or digesting them. At other times they help to repair a break in the skin. If a splinter gets into the skin, the white blood cells form a white pus around the splinter and remove it. In fact, the white blood cell has been referred to as a kind of *Jack-at-all-trades*. In the human community there are certain persons who reach the positions of *teachers, lawmakers, and governors*; they instruct and direct the other members of the community. Just so, in the community of cells, there are certain cells called *nerve cells* (see Fig. 10) that have the duty of governing and directing the other cells. The nerve cells are most abundant in the brain. Large cities have many *scavengers*. Likewise in the human body, a community composed of millions of cells, there are certain *cells in the skin and the kidneys* which have this duty. They are continually removing impurities from the body.

Division of Labor. — There is a great advantage in each cell of the human body *having its special work*, instead of having to do *everything for itself*, as each ameba cell must do. *Under this system each cell can do its own work better than a cell of any other kind can do it.* Among wild tribes there is very little division of labor. Each man makes his own weapons, each knows how to weave coarse cloth, how to cook, how to farm, etc. Savages do not have as good weapons as do people who leave the making of weapons to certain men whose special business it is. What kind of pocketknives or pencils do you think the boys of this country would have if each boy had to make his own pocketknife or pencil? What kind of scissors and thread would the girls have if each girl had to make them herself? Our muscle cells can contract better than the

ameba; the cells in the lungs can absorb oxygen better than the ameba. We have just as great an advantage in digestion, feeling, and other processes; for the ameba eats without a mouth, digests without a stomach, feels without nerves, breathes without lungs, and moves without muscles.

Definitions. — In each chapter of this book you will study a certain part of the body, learn where it is, how it looks, and how it is constructed; this is **anatomy**. In the same chapter you will study the use of the part; this is **physiology**. Lastly, you will learn how to take care of each part; this is **hygiene**. A part of the body which is somewhat separate from surrounding parts, and has special work to do, is called an **organ**; the special work which the organ does is called its **function**. The eye is the organ of sight. The skin is an organ; its function is to protect the body. Supply the words "anatomy," "physiology," and "hygiene" in their proper places in this sentence: — treats of health; — treats of functions; — treats of the structure of the body. Everything in the world belongs to one of three kingdoms, — *animal, vegetable, or mineral*. Animals and vegetables have organs and are placed together in the **organic** kingdom. Minerals have no organs and are said to be in the **inorganic** kingdom. *The chief difference between animals and plants* is that plants get their food from the mineral kingdom and animals get their food from the vegetable kingdom.

The Tissues. — *As the organs have different functions, they must have different structures that they may be adapted to their work.* Just as a house must have brick for the chimney, shingles for the roof, and nails to hold the timbers and other parts together, so the body has various tissues to serve different purposes. The bones must not be constructed like the muscles, and the muscles cannot

be like the skin. The chief work of the cells is to construct the tissues and repair them. During life changes are constantly going on. Careful little workmen are keeping watch over every part of the body; nimble little builders are busy in repairing and restoring. No sooner is one particle removed than another takes its place. In one direction the cells, acting as sextons, are hurrying away matter which is dead; in the other direction the unseen builders are filling the vacant places with matter that is living.

The Seven Tissues.—There are seven kinds of tissues. Two of them, the muscular and nervous tissues, are called the *master tissues*, since they control and expend the energies of the body. The other five tissues are called the *supporting tissues*, since they supply the energy to the master tissues, support them in place, nourish and protect them.

The Master Tissues.—The **muscular tissue** consists chiefly of rows of cells placed end to end (Fig. 9). These cells have the remarkable property of becoming broader and shorter when stimulated by impulses from nerve cells.

The **nerve tissue** consists of cells with long, spiderlike branches (Fig.

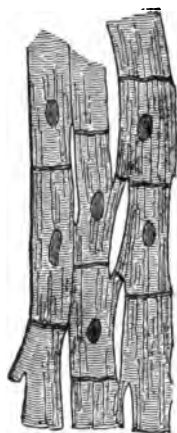


FIG. 9.—THREE MUSCLE FIBERS from the heart (showing the nuclei of six cells).



FIG. 10.—NERVE CELLS, showing their branches interlacing.

10). Some nerve cells have branches several feet long: so long that they go from the backbone to the foot. The branches are called *nerve fibers* (Fig. 142). They are so small as to be invisible to the unaided eye, but a number of fibers from different nerve cells are usually bound together, forming a thread called a *nerve*, which is large



FIG. 11.—CONNECTIVE TISSUE CELLS removed from among the fibers of Figure 12.

n, c, nucleus; b, branches.

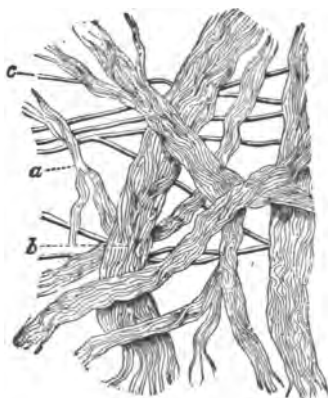


FIG. 12. — CONNECTIVE TISSUE FIBERS.

a, b, bundles of white fibers; c, a yellow fiber.

enough to be seen. The greatest collection of nerve cells in the body is in the head and is called the *brain*. The largest nerve in the body leads from the brain, and is called the *spinal cord*. It occupies a tube formed by the backbone. The spinal cord is not made of fibers alone, for it contains many nerve cells also. Did you ever notice the spinal cord of a hog? Describe the brain of a hog or an ox, if you ever saw one. A human brain has the same general appearance. Nerve fibers which carry impulses *to* the nerve cells are called *sensory fibers*. When the other cells are hungry or tired, they let the brain know through the sensory fibers. The nerve fibers which carry impulses *from* the nerve cells are called *motor fibers*. The

organs are set to work by impulses through the motor fibers. You will next study the five **supporting tissues**.

Connective tissue, like all other tissues, *contains cells* (see Fig. 11), but it consists chiefly of fine fibers. These fibers are of two kinds, — very fine *white fibers which are inelastic*, and larger *yellow fibers which are very elastic* (see Fig. 12). Connective tissue is found in every organ, binding together the other tissues and cells. It is interwoven among the muscle cells, and the tendons at the ends of the muscles are composed almost wholly of it. If every other tissue were removed, the connective

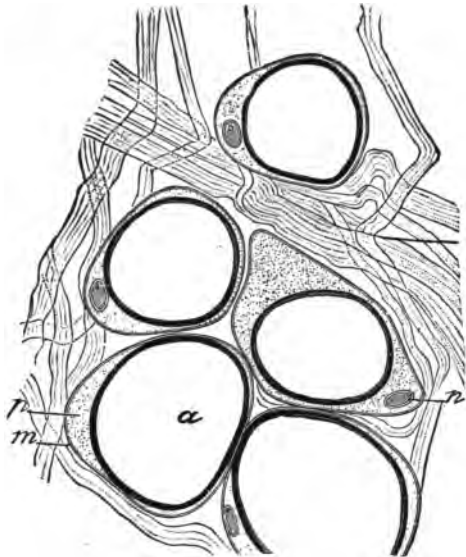


FIG. 13. — FATTY TISSUE. Five fat cells, held in bundles of connective tissue fibers.

a is a large oil drop; *m*, cell wall; nucleus (*n*) and protoplasm (*p*) have been pushed aside by oil drop (*a*).

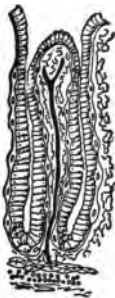


FIG. 14. — EPITHELIAL TISSUE; cells forming two glands in wall of stomach.

tissue would still give a perfect model of all the organs. How abundant this tissue is in the skin may be known from the fact that leather consists entirely of it.

Fatty (Adipose) Tissue. — Fatty tissue is formed by the deposit of oil in connective tissue cells (see Fig. 13). Fat is held in meshes of connective tissue fibers. That fatty tissue consists not only of fat but of fibers



FIG. 15. — SIX GLAND CELLS, shrunk after activity; (at right) rested, full of granules.

also, is shown when hog fat is rendered into lard, certain

tough parts called "cracklings" being left. What is the difference between beef fat and tallow?



FIG. 16. — EPITHELIAL TISSUE (epidermis of skin).

Epithelial tissue consists of one or more layers of distinct cells packed close together (see Fig. 16). It contains no connective tissue or other fibers, and is the simplest of the tissues. Epithelial tissue forms the outer layer of the skin, called the *epidermis*, and the mucous membrane lining the interior of the body (Fig. 7). It contains no blood vessels, the *epithelial cells obtaining their nourishment* from the watery portion of the blood which soaks through the underlying tissue. Epithelial cells are usually transparent; for instance, the blood is visible beneath the mucous membrane of the lips. The finger nails are made of epithelial cells, and they are nearly transparent.

One class of epithelial cells form

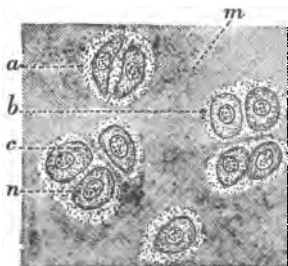


FIG. 19. — CARTILAGINOUS TISSUE. A thin slice highly magnified.

a, b, c, groups of cells; *m*, intercellular substance.

protective coverings (Fig. 16); the other class form the lining of glands (Fig. 14). Glands are cavities (Figs. 17, 18) whose walls (Fig. 14) form either useful fluids called *secretions* to aid the body in its work, or harmful fluids called *excretions* to be cast out. Most glands empty their fluids through tubes called *ducts*.

Cartilag'inous tissue is tough, yet elastic. Cartilage or gristle may



FIG. 17. — GLANDS in the form of tubes.

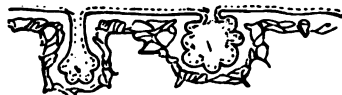


FIG. 18. — GLANDS shaped like a pouch.

be readily felt in the ears, the windpipe, and the lower half of the nose. This tissue consists of *cartilage cells embedded in an intercellular substance through which run connective tissue fibers* (see Fig. 19). If yellow fibers predominate, the cartilage is yellow and very elastic, as in the ear; if white fibers predominate, it is white and less elastic, as in the pads of gristle between the bones of the spinal column. Cartilage is to prevent jars, and, in movable joints, to prevent friction.

Bony (Osseous) Tissue. — Apparently solid bone is seen under the microscope to contain many minute cavities (Fig. 20). *In these cavities the bone cells lie* self-imprisoned in walls of stone; for these cells have formed the bone by depositing limestone and phosphate of lime around themselves. There are *minute canals* (3, Fig. 20), however, through which nourishment comes to the cells. The watery portion of the blood passes through these small canals from the blood vessels that flow through *the larger canals* (1, Fig. 20). Bone cells may live for years, although some of the other cells of the body live only a few hours.

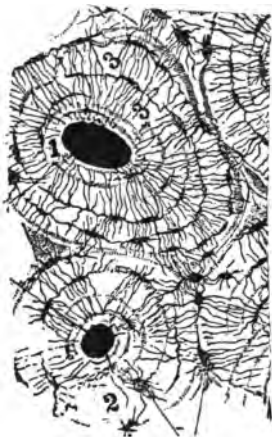


FIG. 20. — BONY TISSUE. Thin slice across bone.

Larger blood tubes pass through the large holes (1); the cavities containing bone cells lie in circles, and are connected by fine tubes (3) with the larger tubes.

THOUGHT QUESTIONS. — Value of Health. 1. Write five blessings in youth or later in life that result from good health. 2. Write five things that most people value more than health, since some people lose their health to obtain them. 3. Write five results of sickness. 4. Think of ten grown persons at random. How many of them are in sound health? 5. What proportion of people live out “threescore and ten” years?

The body is kept alive and warm by burning, or oxidation. Oxygen gas is a part of the air. We breathe it in every minute of our existence. It is carried by the blood to all the tissues. Not one of the cells could work without oxygen. Without it the body would soon be cold and dead, for oxygen keeps the body alive and warm by uniting in the cells with sugar, fat, and all other substances in the body except water and salt. Oxygen burns or consumes the substances with which it unites, and the process is called *oxidation*. Hence the cells have to be continually growing and multiplying to repair the tissue and replace the material used up by oxidation. Sugar and flour and fat oxidize, or burn, outside of the body, as well as in it, as can be proved by throwing them into a fire. Water and salt are two foods that do not burn in the body. Water puts out a fire instead of helping it, and so does salt. You may have thrown salt into a fire or on a stove and noticed that it popped like sand, but did not burn.

The cells need the oxygen of fresh air; they need food for the oxygen to unite with, but *they are injured by many substances called poisons*. Arsenic destroys the red blood cells. Strychnine attacks the nerve cells in the spinal cord. Alcohol attacks the epithelial cells lining the stomach and, when it is absorbed, attacks the nerve cells (see Fig. 160) and other cells. Morphine attacks the nerve cells. These substances are poisons. Wine and beer contain the poison called alcohol. Tobacco contains a poison called nicotine.

Experiments. — 1. Light a candle and bring a glass pickle jar down over it. What happens? Why? 2. Pass a glass tube or a long straw or the hollow stem of a weed into a jar through a hole in a piece of cardboard. Send one long breath into the jar. Place the jar mouth downward on a

table. Slip the cardboard away. Slide the jar to the edge of the table and pass a lighted candle into it. What happens? A gas called *carbon dioxid* is formed by fires and by oxidation in our bodies. This gas smothers a fire and destroys life.

THOUGHT QUESTIONS.—**The Tissues.** 1. Which tissue has the largest proportion of substance between the cells? (Fig. 20.) 2. Which tissue has no fibers, but is composed almost wholly of cells? 3. Which tissues have cells without branches? With branches? 4. Does fat accumulate in the body within the cells or outside of them? 5. How does blood resemble a tissue? (Fig. 76.) 6. Which cell has the greatest variety of functions? Which cells are very active; which moderately active; which very inactive? 7. Give an instance of a cell of one kind of tissue becoming a cell of another kind of tissue (Fig. 13). 8. How does a tissue grow? Does a scar on a child enlarge as its body grows? 9. The elasticity of the skin suggests that it contains what kind of fibers?

WRITTEN EXERCISES.—Draw a series of seven pictures to show the seven tissues (Figs. 9, 10, 12, 13, 16, 19, 20). Write the "Autobiography" of a White Blood Cell (see also pages 97 and 128). The Rewards of Caring for the Health. A Railway Wreck caused by Alcohol (description and reflections). Health and the Disposition. Which is more Important, a Thorough Knowledge of Geography or of Physiology?

CHAPTER II

THE SKIN

The Chief Function of the Skin. — The skin has several functions, or uses. The one which is most easily seen is that of *protection* of the organs below it. The skin is *thickest* on the palms of the hands and on the soles of the feet, where protection is most necessary. It is *thinnest* at the joints and wherever rapid motion is required, as over the eyelids. At the ends of the fingers and toes, where unusual protection is needed, it grows into *shieldlike plates* called *nails*. On the head the skin puts forth a thick covering of hair which aids the skull in protecting the delicate brain. A strong suit of clothes is a good protection for the body; but the skin is even a better protection, for it has the special adaptations just mentioned, and is stronger than one might suppose from its appearance.

That the skin is *capable of great stretching* is shown in cases of the dropsy; that it will *not contract beyond a certain limit* is shown by the wrinkles of very lean or old people.

General Structure of the Skin. — If you pinch up a fold of the skin on the back of the hand, you will notice that the skin there is about one tenth of an inch thick, the fold showing a double thickness. When a person burns himself so as to make a blister, the outer layer of the skin is separated from the skin below. The covering of the blister is much thinner than the skin, being hardly thicker

than paper; neither is it so elastic as the fold of skin tested on the back of the hand. It is much lighter in color, and is not sensitive like the pink and tender layer seen beneath the blister. Hence we conclude that the skin must be in two layers. This outer layer is called the

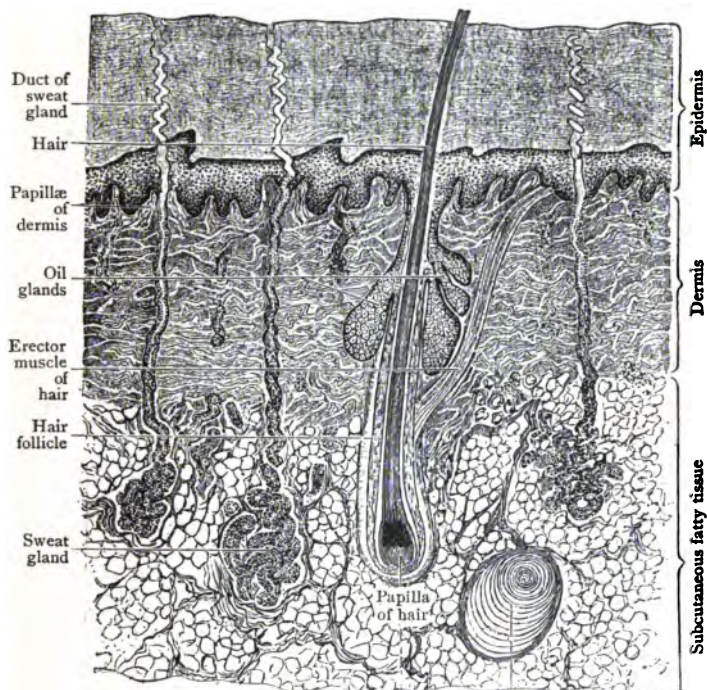


FIG. 21. — SECTION OF SKIN, highly magnified. (Cunningham.)

epidermis; it is *thinner, more transparent, and less elastic* than the inner layer, or dermis. The epidermis is composed of epithelial cells packed close together (see Fig. 22). The **dermis**, or inner layer, is a closely woven sheet of *connective tissue* containing a great number of *sweat and oil glands*, *roots of hairs*, *blood vessels*, *absorbent vessels* (lymphatics), and *nerves* (see Fig. 21). The dermis is

sometimes called the true skin because it is of greater importance than the epidermis. It is united loosely to the underlying organs by a layer of connective tissue. It is in this layer that fat is stored.

Papilla. — The upper surface of the dermis rises into a multitude of projections (see Fig. 22, also colored Fig. 14)

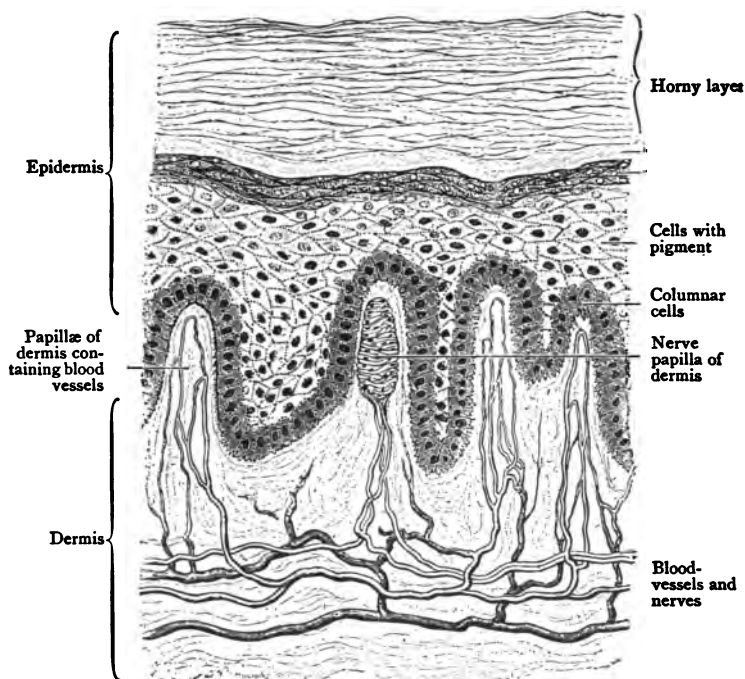


FIG. 22. — SECTION OF EPIDERMIS, with papillæ of dermis.

called *papillæ* (singular, papilla). The epidermis fits closely over them and completely levels up the spaces between them except on the palms and the soles. Here the papillæ are in rows, and there is a fine ridge in the skin above each row of papillæ (Fig. 29). In the papillæ are small loops of blood vessels and sometimes a nerve fiber.

The epidermis is composed of a mass of cells held together by a cement resembling the white of an egg. The cells near the surface are hard and flattened; those deeper down near the dermis are round and soft (see Fig. 22). These cells are living cells. They are kept alive by the nourishment in the watery portion of the blood which soaks through from the blood tubes in the neighboring papillæ. Hence these cells are growing cells; they subdivide when they reach a certain size, and replace those wearing away at the surface, thus constantly repairing the epidermis. The dry outer cells wear away rapidly. They have no nuclei and are dead cells. The new cells forming beneath push them so far away from the dermis that nourishment no longer reaches them, and they die.

Pigment. — *The cells* in the lower layers of the epidermis contain grains of coloring matter, or pigment. Africans have dark and abundant pigment (Figs. 23, 24). The varying amount and tint of the pigment cause the red skin of the Indian race, the yellow skin of the Chinese, the brown skin of the Malay. The pigment in neighboring cells sometimes develops to a marked degree and forms what is called a freckle. *Al-*

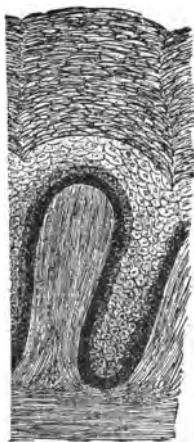


FIG. 23.—EPIDERMIS
OF NEGRO.



FIG. 24.—EPIDERMIS
OF CAUCASIAN.

binos, or persons entirely without pigment, have pallid complexions and pink eyes. They are found in all races; there

are some Albino negroes. Is the pigment *in* the cells or *between them*? (See Fig. 22.) The amount of pigment is increased by long exposure to sunlight. This effect is noticeable at the wrists. The *sunlight is also a great purifier of the skin*. So a person who never exposes the skin to sunlight is likely to have a dark or dingy skin from the impurities in it, or because the blood circulating through it is dark and impure.

The hair is really the epidermis grown into fine rods or threads. Each hair grows from a moldlike *papilla* called

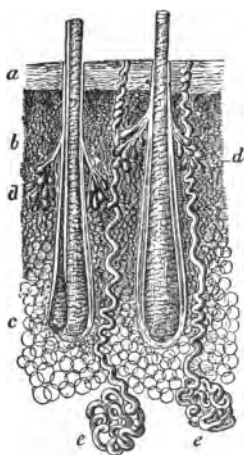


FIG. 25.—TWO HAIRS IN FOLLICLES.

d, oil glands; *e*, sweat glands.

a *hair bulb*, which, unlike ordinary papillæ, is at the bottom of a little pit called a *hair follicle* (see Fig. 25). The cap of epidermis formed on such a papilla does not fall off, but remains, and new cells are formed beneath it until the cap is pushed up into a long, slender rod of epidermis (Fig. 26). In old age the pigment in the hair is replaced by air. The use of dye upon gray hair is in bad taste and is now seldom seen. One or more *oil glands open into each follicle* (see Fig. 25).

Blood vessels and a nerve fiber go to the root or bulb from which the hair grows. The hair will grow until this papilla, or bulb, is destroyed. It is impossible to stop the growth of superfluous hair unless the hair papillæ are destroyed with an electric needle, such is the vitality of hair; yet many men, by overheating the head and cutting off the circulation with tight hats, destroy much of the hair before reaching middle age. The health of the hair can-

not be restored except by going bareheaded most of the time. This frees the circulation, and the sunlight and cold air stimulate the cells of the scalp. The hairs, or rather the follicles around them, are provided with *tiny muscles with which the hairs are made to stand on end* (Fig. 21). Why does trimming the ends of the hair have no effect upon its growth? Why is pulling the hair painful, while cutting it is not felt?

Experiment 3. The minute hairs scattered over the body aid greatly in touch. Let a classmate rest his hand upon the back of the desk, while you touch a hair on his hand to find whether or not he can feel it.

The uses of the hair are: 1, to *protect* from sudden changes of temperature; 2, to serve as an *aid to the sense of touch*; 3, to protect sensitive parts from *dust*, as the eyelashes, and the hairs in the nostrils and ears.

The nails are dense, thick plates of epidermis growing from a number of papillæ situated in a groove, or fold, of the skin; there are a number of fine papillæ along the bed from which the nail grows (Fig. 27). Since it grows from its under side as well as from the little fold of skin at its root, the nail is thicker at the end than near

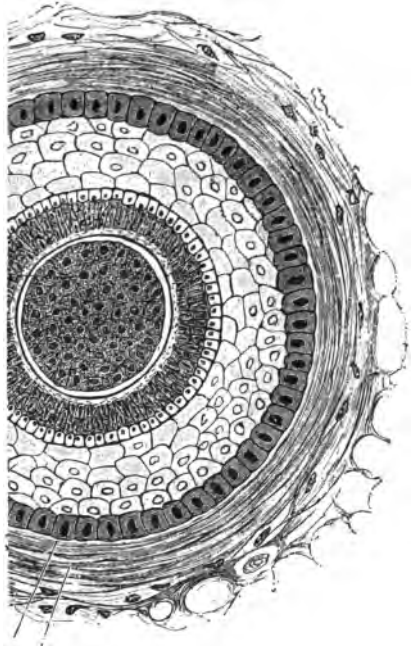


FIG. 26.—SECTION OF HAIR FOLLICLE, with hair in center surrounded by layers of the follicle. Highly magnified.

the root. The nail moves forward as it grows. It moves its whole length in four months, hence we have three sets

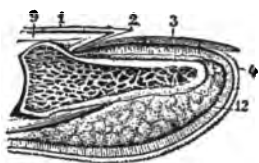


FIG. 27. — SECTION OF NAIL and parts beneath.

of nails each year. Make a mark on a nail and observe the number of days it takes to move a certain distance. If not pressed back at the root, the skin may be dragged along by the nail and pulled loose into hangnails; if the skin is

pressed back too much, white specks or flaws appear from imperfect nutrition. Attempt to pick up a small object without using the nails.

The oil glands empty into the hair follicles (see Fig. 25). They form an oil from the blood that *keeps the hair glossy and the surface of the skin soft and flexible*. The oil likewise prevents the absorption of water. In the palms and soles, where there are no oil glands, the skin may become white and swollen when kept long in water. In some places, as upon the nose and chin, where the hairs are very small, the oil glands are large and may be said to open directly upon the skin. Such oil glands may become swollen with oil and dirt, which form what are called *black heads*. *Keeping the face clean by thorough washing, and stimulating the relaxed glands by dashing cold water upon the face*, will cure this condition. Hair oil should never be used upon the hair, as the oil soon becomes rancid, and besides causes dust and dirt to stick to the hair. The use of hair oil and powdered wigs has been discontinued along with many other artificial customs common a century ago.



FIG. 28. — TWO SWEAT GLANDS with their ducts.

The sweat glands (Fig. 28), like the hair bulbs, are deep in the lowest part of the dermis. *A sweat gland has the form of a tube coiled into a ball*; it is connected with the surface by the sweat duct, which is a continuation of this tube through the two layers of skin. The opening of the tube upon the surface is called a *pore* (Fig. 29). The perspiration is formed in the coiled part. It evaporates as fast as it flows out through the pores, if the secretion is slow; but if poured out rapidly, it gathers into drops. The perspiration is chiefly water, containing in solution several salts, including common salt and a trace of a white, crystalline substance called *urea*.



FIG. 29. — PORES on ridges in palm of hand.

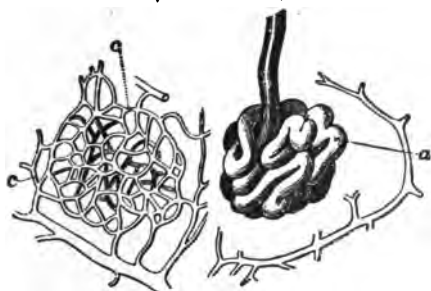


FIG. 30. — COILED TUBE OF SWEAT GLAND, removed from network of capillaries (c) which surrounded it.

The material for the perspiration is furnished by the blood flowing around the gland in a network of fine tubes (Fig. 30). The amount of the perspiration is controlled in two ways: by *nerves that regulate the activity of the epithelial cells lining the*

gland, and by nerves that regulate the size of the blood vessels supplying the gland.

Experiment 4. By holding a piece of cold glass near the hand, or by placing the cheek near a cold window pane, invisible perspiration may sometimes be made visible.

THOUGHT QUESTIONS. — Freckles, Warts, Moles, Scars, Proud Flesh, Pimples, Black Heads. By applying the anatomical facts already learned, you can explain the above-named peculiarities sometimes found on the skin. A rough prominence formed by several papillæ growing through the epidermis at a weak spot and enlarging is called a —. Small patches of pigment developing on the hands and face from much exposure to the sun are called —. The growth of exposed dermis sprouting through an opening in the epidermis due to accident is called —. (This should be scraped off and cauterized to aid the epidermis to grow over it again.) Sometimes a cut heals in such a way that no epidermis, and therefore no pigment cells, cover the place of injury, which is occupied only by white fibrous tissue (cicatricial tissue) of the true skin. In this case the mark left is called a cicatrice or —. If pores or the openings of oil glands become clogged, but not enlarged, little swellings called — may result. An enlarged pore filled with oil and dirt is called a —. A spot present since birth, dark with pigment, and often containing hairs and blood vessels is called a —.

Muscles of the Skin. — The capillaries of the skin are so arranged that they lie between bands of muscular tissue. These muscles can be made to contract and compress the

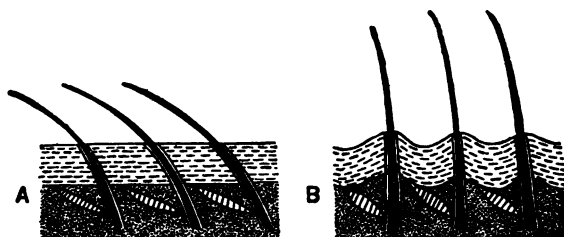


FIG. 31. — MUSCLES ATTACHED TO HAIR FOLLICLE. (Diagram by Jegi.)

A, at rest and hairs in usual position; **B**, muscles contracted and hairs standing on end. Rising of the hair protects beasts from cold, but "goose flesh" fails to protect man.

capillaries in such a way as almost entirely to empty them. What is the position of the muscles which cause the hair to stand on end in cold weather? (Figs. 21, 31.) These muscles also cause goose flesh in a prolonged cold bath.

Nerves in the skin are of several kinds: 1, nerves that regulate the activity of gland cells; 2, nerves that

give the sense of touch and pressure ; 3, nerves that control the muscles in the skin ; 4, nerves that give the feeling of heat ; 5, nerves that give the feeling of cold.

Thermic Nerves. — Although cold is merely the absence of heat, there are *two kinds of temperature nerves*. This can be proved by touching the skin with hot and cold needles. Certain small

areas of the skin are found sensitive to heat but not to cold, while with other areas the reverse is true. The skin is more sensitive to chilling than to heating. An object that *conducts heat rapidly feels cooler* to the skin than one at the same temperature that

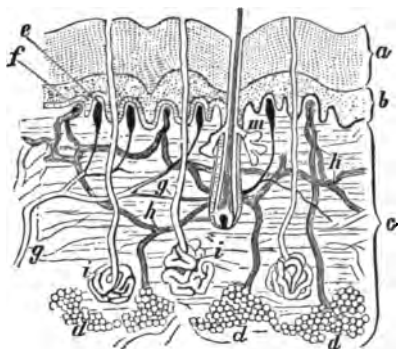


FIG. 32. — SKETCH OF SKIN for blackboard or notebook.

conducts heat slowly. A metal or stone door knob feels cooler than the door. The temperature nerves become fatigued quickly. Hence, water which may seem painfully hot or cold to one entering a bath will be easily borne after a few seconds have passed.

Experiments 5. — The information given by the thermic, or temperature, nerves is relative. An object is felt to be cold if it is colder than another object which has just been in contact with the skin at the same point. On this principle, can you arrange an experiment in which a vessel of water will feel cold to one hand and warm to another at the same time ? 6. Draw the end of a cold (or hot) wire along the skin. Does it feel cold all the time ? (Fig. 162.)

Regulation of Temperature. — As is well known, rapid running or violent exercise of any kind causes profuse per-

spiration. What is the connection between these two occurrences? Is there a reason why one always follows the other? The body is so constructed that the organs work best at a temperature of 98.6° Fahr. If its temperature rises a little above 98.6° , the body cannot do its work well; if it rises much above or falls much below that limit, life may be in danger. Muscular activity is carried on by a kind of burning process which would raise the temperature higher than 98.6° if there were not some provision for cooling the body. The sweat glands are connected with the brain by means of nerves, and when the body has too much heat a *nerve impulse from the brain causes the sweat glands to form sweat more rapidly*. Heat and exercise may cause the activity of the sweat glands to increase forty times the usual rate. The evaporation of the sweat cools the body; for a large amount of heat is required to evaporate a small amount of water. This is shown by the cooling effect of sprinkling water on the floor on a warm day. By fanning, we hasten the cooling of the body.

Exercise causes us to breathe faster and causes much blood to flow through the skin. Both of these effects aid in cooling the body, for the cool air is drawn into the lungs, becomes warm, and takes away heat when it leaves; and the warm blood flowing in the skin loses some of its heat to the air in contact with the skin. The more blood goes to the skin, the more blood is cooled. The body as a whole may be cooler, but *we feel warmer when there is more blood in the skin because of the effect of the warm blood upon the thermic nerves*. There are no thermic nerves except in the skin and mucous membrane, and the body has practically no sensation of heat and cold except from the skin or mucous membrane.

Experiment 7. A moist cloth placed on the bulb of a thermometer will cause the mercury to fall several degrees while the cloth is drying.

Effects of Alcohol upon the Skin.— That alcoholic drinks make the skin red is commonly noticed. Often *the skin is flushed* by one drink ; the blood-shot eyes and purple nose of the toper are the results of habitual use. Can you explain why alcohol brings a *deceptive feeling* of warmth? Why does alcohol increase the danger of freezing during exposure in very cold weather?

THOUGHT QUESTIONS. — The Functions of the Skin. 1. State a fact which shows that the skin is a protection ; gives off offensive substances ; regulates the temperature. 2. Is it more necessary for mental workers to bathe often or to change clothes often? Physical workers? 3. Do you know persons who scorch their hair with hot irons? State the effect. 4. What is lacking in the skin when it cracks or chaps? Why does this occur more often in cold weather?

Effects of Indoor and Outdoor Life.— The plant that grows out of doors has a thick, tough bark, strong stems and leaves. It can survive dry winds, hot winds, frost, hot sun, and drought, while a plant of the same species raised in a hothouse quickly dies if exposed to unfavorable conditions. Every cell and fiber of the outdoor plant has greater vitality and more resistance than the house plant. The same principle applies to animals, and is especially noticeable in human beings. *Those who live much out of doors, exposed to sunlight and pure, cold air, are robust and hardy* ; while those whose occupations keep them constantly indoors, especially if no physical labor is necessary, show by their pale skins, their fat and flabby, or their thin and emaciated bodies, the weakening effect of such a life. We are descended from ancestors that lived in the open air, and it is impossible for a human being to live constantly

indoors without degeneration of the body and shortening of life.

A Well-trained Skin. — We hear a great deal about training the muscles, the brain, the eye, the hand; yet we may fail to realize that the skin also can be trained and its powers developed, or it can be allowed to become weak and powerless. Soundness of the skin is as essential to health as soundness of any other organ. The nineteen square feet of skin covering the body contain 2,400,000 sweat glands. It is plain that *if this vast secreting surface is so weak and easily affected that a slight draft or change in the weather paralyzes its purifying action, the body is subject to many maladies.* With the skin in a healthy condition, the danger of taking most diseases is removed.

Characteristics of a Vigorous Skin. — A healthy skin is neither hard nor flabby, but firm; it is not dry, dingy, rough, or sallow. It is warm, slightly moist, smooth, supple and elastic, and free from pimples and blotches. It perspires freely under the influence of exercise or heat, and reddens quickly when rubbed, or when hot or cold water is applied to it. A person who readily takes cold, who is fearful of drafts of air at all times, probably has a weak skin. To one who has a healthy skin drafts are dangerous only when the skin is moist with perspiration; cold drafts may then do harm. Cold air and cold water are the best means of toughening a tender skin. *A bath is to the skin what gymnastic exercise is to the muscles.* The muscle fibers in the walls of the blood vessels and the nerves controlling them need exercise as well as the rest of the body. Describe a lazy skin.

If we followed the outdoor life and wore the scanty clothing of savage races, the rains, the cool air, and the sunlight would keep our skins vigorous and sound. But inactivity

of the muscles allows the sweat glands to become stopped up. Thick and heavy clothing and overheated rooms prevent the nerves from being stimulated by cold air and sunlight. *It is necessary to counteract these weakening conditions by frequent cold bathing.* Even the lower animals bathe: birds, dogs, and many lower animals bathe in the rivers. An elephant sometimes takes a bath by showering water over his back with his trunk.

THOUGHT QUESTIONS. — **The Care of the Skin.** 1. Why does the palm of a washerwoman's hand absorb more water than the back of the hand? Why should a painter keep his hand clean? Why do dyed stockings sometimes cause an eruption? 2. Why is linen used for towels? 3. When is a scar incapable of being affected by freckles or tan? 4. Why can a scar on a negro be white? 5. How may rubber shoes make the feet moist? 6. Why does the heat seem more oppressive in moist weather? 7. Which should usually wear warmer clothing, a farmer or a merchant? 8. Why is baldness more common among men than among women? How do you account for the shape and location of the bald spot? 9. Why should we remove an overcoat or a cloak when we go into a warm room? 10. Why is cold water better than warm water for the daily bath? 11. Show how the wearing away of the outer cells of the epidermis contributes to the cleanliness of the body.

Warm Baths. — For merely *cleansing the body*, warm water is more effective than cold water. Any one who has had experience in washing greasy dishes with cold water and with warm water knows there is a marked difference in their cleansing power. *But warm baths are relaxing, and are best had just before retiring* to prevent danger of taking cold after the bath. If taken at other times, cold water should be dashed upon the skin at the close of the bath. *A warm bath is more suitable than a cold bath for one who is greatly fatigued.* A bath for cleanliness, with the use of soap and tepid water, should be taken at least once a week in cold weather, and oftener

in warm weather. Too frequent use of soap or warm water makes the skin thin and hard and dry.

Cold Baths. — A daily cold or cool bath, although it aids in keeping the skin clean, has for its chief purpose the invigoration of the skin and the *training of it to prompt reaction to cold*. The whole body reacts also. The nervous system is toned up, the lungs draw deep breaths, the appetite is improved, the heart and all internal organs take on renewed activity. *The cold bath replaces the cool breezes that constantly stimulated the skins of our remote savage forefathers.* Such a stimulus is natural, and is followed by no evil effects, such as follow the artificial excitement from drinking alcoholic liquors.

When cold water is applied to the skin, there is a sudden contraction of the blood vessels. This is followed by a dilation of the blood vessels and *a return of blood to the skin, which causes a glow. This is called a reaction.* A cold bath should always be short, as a long cold bath may chill the body too much. If the feet and hands continue cold after the bath, or if the head aches, this shows that the person remained in the bath until after the reaction was finished, and the body had been chilled a second time. A short cold bath, not more than one or two minutes in length, followed by vigorous rubbing until a good circulation is established, is good, even for a delicate person. *Gradually the ability to react improves,* until colder water and longer baths may be used. In the case of very delicate persons, the arms only may be sponged with cold water at first, and the area to which the cold water is applied may be extended little by little at each successive bath for a week. *Persons who easily take cold especially need the training of the skin that results from cold baths.* Muscular exercise also strengthens the circulation. But

it is almost impossible to lead persons with weak and degenerate skins, who shudder at the thought of a draft, to see the error of their ways. If they would never have to expose themselves to cold, they might safely indulge in their love of high temperature, but frequent exposure is inevitable, and such persons have worse colds and have them oftener than people who do not pet and coddle their nerves of temperature. The weaker the skin becomes, the more it needs training, but the more they overheat it instead. Remaining in an overheated, unventilated room more quickly brings on a cold than chilling the body.

The materials of which clothing is made are *linen, cotton, silk, wool, leather and fur, and rubber* for waterproof clothing. Clothing does not give heat to the body, but keeps the body from losing too rapidly the heat generated by the vital processes. *Loosely woven clothing contains air spaces and does not conduct heat away from the body as fast as tightly woven or tight-fitting clothing.* If the body is properly clothed, the temperature of the air between the clothes and the body will be seventy-five to eighty-five degrees, even in freezing weather. *Two things must be considered* in deciding the use of fabrics for clothing: first, whether they *conduct heat* rapidly or slowly; second, whether they *absorb and transmit moisture* rapidly or slowly. Because *woolen conducts heat slowly*, it is usually believed to be the best material for winter wear; but *woolen absorbs and gives up moisture very slowly*; and if sensible perspiration forms, it is kept in as a kind of sheet of moisture covering the body, and conducts away the heat rapidly. *Linen and cotton absorb moisture readily and transmit it rapidly, so that these fabrics keep the body dry.*

Experiments. — 8. Sprinkle water upon a woolen and a cotton cloth. Which absorbs more water? 9. Immerse

the cloths in water and hang them up to dry. Which becomes dry first?

Clothing and Climate. — Many physiologists now hold that cotton and linen are best for underwear, as they keep the skin dry by rapid absorption and evaporation. But in order that the evaporation may not be so rapid as to chill the body, woolen should be worn for outer clothing in cold climates; it is also better suited for underwear in climate and weather so severe that there is little risk of sensible perspiration forming. Why should people with a tendency to perspire freely avoid woolen underclothing?

White or light colors for clothing are best in warm climates and in summer, as they reflect heat and light, while dark colored materials absorb them. White clothing transmits unchanged to the body any light that may penetrate between its threads, while dark outer clothing changes sunlight to heat, which does not affect the skin so favorably as light.

People who go to different climates should change their dress with the climate. Englishmen who go to India, Americans who go to the Philippines or to Alaska, people making trips between the Gulf states and the Northern states, realize this need. Yet there have been absurd instances of disregard of this rule of health. People from northern Europe sometimes bring with them feather beds to sleep under in the warmer portions of the United States and continue to use them.

Clothing and Weather. — The old rules requiring winter underclothing to be put off and resumed at certain dates, were made in a time when the science of hygiene was unknown, and people had no adequate idea of the complexity of the body. As an instance of the working of such rules, a grandmother required a girl for years to wear winter

flannels until a certain date ; the girl always had very bad colds in the spring. She afterward disregarded the rule, acted in accordance with her feelings, and seldom had a cold. If the spring happens to be unusually early, there is no reason why a farmer should *swelter in thick clothing because such clothes were comfortable at that date last year*. Comfort is a guide to the health. *The science of hygiene contains no mechanical rules, but teaches* that observation, reason, and adaptation to climate, season, and individual needs must be the basis of hygienic conduct. On the contrary, the complexity of this science warns us against the inflexible rules by which people with indolent minds or exact, mechanical ways of thinking govern their conduct.

Babies and young children cannot always make their wants known in an unmistakable way. Many young children die every year from lung or bowel troubles brought on by insufficient clothing or bed covering. This may occur in summer because the first part of the night is warm and the covering is not enough to protect the body later against the cold. Which cools more quickly when hot, a small pebble or a large stone? The one which has the greater cooling surface, in proportion to its size, cools more quickly. Thus we see why infants suffer more from exposure than adults. As food is the source of the bodily heat (which clothing only serves to retain), babies must be fed more often than adults.

EXERCISES IN WRITING. — Sunshine. Fashion and Health. Simon says Wig-wag. Tight Shoes. Health and Country Life. The Face and what it Betokens. Artificial Complexions: how they are put on. Natural and Artificial Beauty. The Drunkard's Home and Life therein. Two Ways of Spending an Evening. Exposure and Coddling (see also page 120).

Oral Review (*by the Competitive Method*).—These questions require merely “yes” or “no” for an answer. The teacher can make similar questions for the other chapters. An oral review should be given at the end of each chapter. The teacher states the question, pauses awhile for pupils to think, and says “hands up.” Those who wish to answer “yes” will raise their hands. If they are wrong, they will go to the rear of the room, or be seated if the class is standing in line. If those who failed to raise the hands are wrong, they leave the line. When only one fifth of the class are left in the contest, their names are recorded, and the whole class take their places for another trial.

Are there any fibers in the epidermis? Do all the cells of the epidermis have nuclei? (Fig. 23.) Are all of the cells of the epidermis flattened? Is the pigment in the cells? Between them? Are all cells colored? Do the oil glands usually open directly on the surface of the skin? Is an oil gland like a bag? Like a tube? (Same questions for sweat glands.) Is the skin on any portion of the body without oil glands? Are the papillæ arranged in lines in any part of the skin? If several papillæ grow through a weak spot in the epidermis and form a rough prominence, is it called a freckle? A pimple? A wart? Is there only one kind of temperature nerves? Are there two kinds? Raise your hands at the name of each of the following qualities that belong to a healthy skin: flabby, elastic, pimply, rough, smooth, warm, pink, sallow. Does soft, loosely woven clothing keep the heat in the body better than tightly woven clothing? Does woolen absorb moisture faster than cotton? Does woolen give off moisture as fast as cotton? Does the dermis have more of blood vessels than of anything else? Of nerves? Of connective tissue? Are there any blood vessels in the epidermis? Does perspiration take any solids away from the skin when it evaporates? Is heat more oppressive in dry weather? Wet weather? Is perspiration more abundant in damp weather? Is visible perspiration more abundant then? Does an abundance of permanent wrinkles show that the body is too small for the skin? Too large? Can the mucous membrane do part of the skin's work for it? Does the name of the pit in which the hair grows begin with *g*, — *r*, — *h*, — *o*, — *f*?

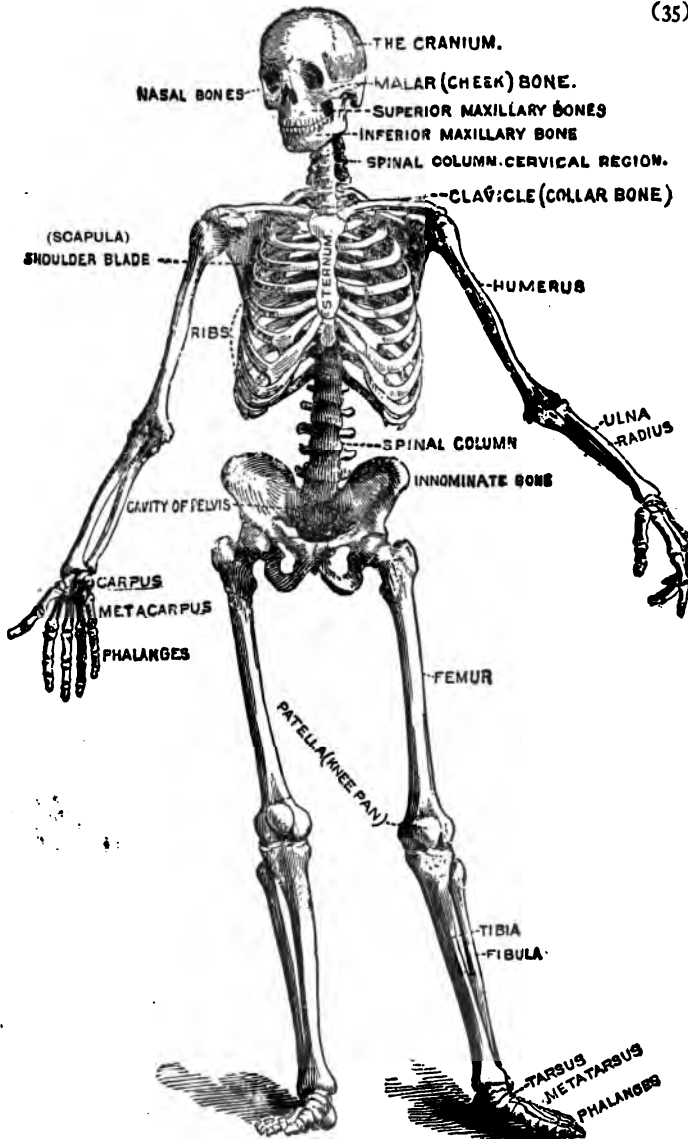


PLATE I. FIG. 33. — THE SKELETON.

State the scientific (Latin) name of the following bones: skull, cheek bone, upper and lower jawbones; collar bone, shoulder blade, breastbone; bones of upper arm, lower arm, wrist, palm, fingers; hip, thigh, kneecap, shin bone, splint bone; bones of ankle, instep, toes.

CHAPTER III

THE SKELETON

Observational Study of Hand and Arm (Fig. 33). — By touch and sight we find that each *finger* has — bones, and that the thumb has —, making — in all for one hand. There are — bones in the *palm* of the hand. The palm bones of the — are bound firmly together, but the palm bone of the — is free to move in any direction. Thus the — may be brought opposite to each of the —. Attempt to pick up and handle objects without using the thumb. What is the result? The palm bones cannot be traced through their whole length by feeling them, since in the upper half of the palm the flesh is very thick.

Is the division between the palm and the *wrist* equally plain on the palm side of the hand and the back of the hand? The wrist bones are nearly cubical, and are arranged in two rows. Rapidly bend and straighten the fingers of one hand, and with the fingers of the other hand find whether you can feel a firm cord crossing each knuckle and running toward the wrist (Fig. 34). When the cords are tightest, the fingers are bent backward. Can you see the cord rise as you work the fingers? There are cords on the palm side to bend the fingers; but because of the thick skin in the palm, it is more difficult to see their position. However, in the wrist at the base of the palm, you can feel two hard wrist bones that confine the cords in the softer space between them. You may also observe the cords

moving on the palm side of the wrist when the fingers are moved (Fig. 34). We have seen that the fingers are moved backward and forward by tightening first one set of these cords, and then the other. These cords are called *tendons*. One end of each tendon is attached to a bone and the other end is attached to a muscle. It is plain that the muscles that move the fingers are somewhere above the wrist. Can you locate them by feeling them while you move the fingers? (A muscle shortens, thickens, and hardens when it moves a bone.)



FIG. 34. — MUSCLES AND TENDONS of forearm.

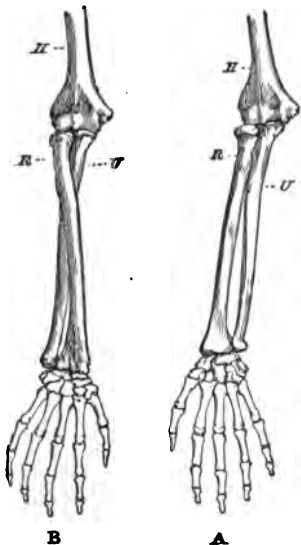


FIG. 35. — BONES of right forearm.

A, palm; B, back of hand.

In how many directions do the *joints* between the fingers and palm allow the fingers to move? Each finger has two joints between its three bones. In how many directions does each of these joints allow motion? Does the wrist joint allow more freedom of motion back and forth, or from side to side?

Rest the elbow on the table, keep the wrist straight, and try whether the hand will rotate. What fraction of a complete rotation does the hand make? To understand the rotation, study Figure 35. You will see that there are

two bones in the forearm. The ends of these bones may be felt immediately back of the wrist joint as bumps under the skin. The larger bump, or knob, is on the little finger side of the arm. The first bone of the forearm is attached to the elbow and the second bone lies by the side of it, and is bound to it near the elbow (see Fig. 45). The second bone turns around the first, and the hand, being attached to this bone, turns with it (Fig. 35).

Bend the right elbow and at the same time feel *the upper arm* with the left hand. The large muscle that can be felt to swell and harden is called the *biceps*. Repeat the movement, but clasp the elbow instead of the upper arm. Do you feel a large tendon that goes from the biceps to the forearm? (Fig. 55.) Straighten the arm and at the same time feel the side of the upper arm opposite to the biceps. Do you feel a large muscle that is contracting? You can perhaps feel that there is a single bone between the shoulder and elbow, and that it is round and smooth (Fig. 33). We find that to bend a joint the muscle on one side of the arm contracts, and to straighten it a muscle on the other side contracts.

Review of Bony Tissue. — Where are the bone cells? How does nourishment reach them? How has the mineral part of the bones been deposited? How long may bone cells live?

Need of the Body for a Framework. — The jellyfish and a few other animals in the sea are soft throughout. The slug and a few other land animals have no hard or stiff parts. *An animal without hard parts cannot stand erect, and must move slowly and with difficulty.* The human body without its skeleton would lack its beautiful proportions, its graceful motions, and dignified bearing. There are two kinds of skeletons among animals: the

outside skeletons (examples : the crawfish, the grasshopper); the *inside skeletons* (examples : fish, birds, and beasts). The inside skeleton allows more freedom of motion and is by far the better kind.

Forms and Uses of Bones. — The three chief *uses of bones* are *protection, motion, and support*.

In order to fulfill these purposes, the bones must have different sizes, shapes, and positions. The bones are classed by *shape, as long, flat, and irregular*. Those whose chief use is to *protect* are *broad and flat*. The bones which *furnish support* are *thick and solid*; those designed to *aid in motion* are *long and straight*. There are two hundred and six bones in the adult skeleton, if we include six small bones in the ear.

Structure of Bones. —

The structure of a long bone is shown in Figure

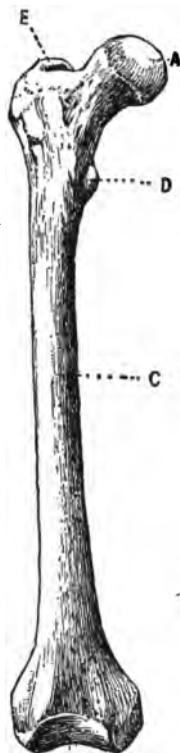


FIG. 37.—FRONT VIEW OF LEFT FEMUR.

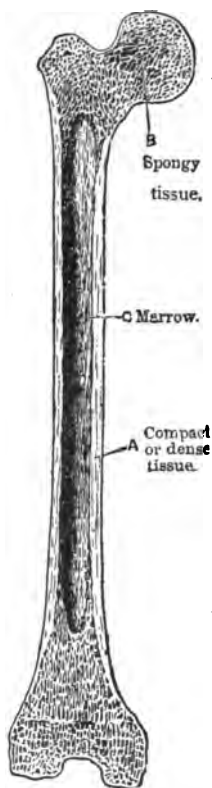


FIG. 36.—FEMUR, sawed lengthwise. The red blood cells are formed in the red marrow of the spongy part.

36. It has a long, *hollow shaft* of hard, compact bone, and *enlarged ends* composed of spongy bone. The hollow in the shaft is *filled with yellow marrow*, which is composed of blood vessels and fat, and aids in nourishing the bone. The

long bones are found in the limbs (Fig. 33). The flat bones and irregular bones are spongy inside, and hard and compact near the surface. For instance, in the skull the outer and inner surfaces form two armorlike plates, and the spongy layer between them lessens the jar to the brain from a blow upon the head. There is a ~~red~~ *red marrow* in the cavities in the spongy parts of bones (Fig. 36). *The red blood cells are formed in this marrow.* The bones have a close-clinging, fibrous covering composed of connective tissue and blood vessels. It is called the *periosteum*.

Composition of Bone. — Experiment 10. *Place a bone in a hot fire and let it remain for three or four hours.* It will keep its shape however long you burn it; but unless you handle it carefully when you take it out, it will crumble to pieces. If not thoroughly burned, the bone will be black from the carbon of the animal matter still left in it.

Experiment 11. Obtain a slender bone like the rib of a hog or the leg bone of a fowl, and put it into a vessel containing strong vinegar or two ounces of muriatic acid and a pint of water. Leave it there for four days. When the bone is taken out, it will be so soft that it can be tied into a knot. The acid may be washed off, and the bone preserved in a bottle of alcohol or glycerine.

These experiments show that the bones contain a *mineral or earthy substance*, which makes them hard and stiff, and a certain amount of *animal matter, called gelatine*, which binds the mineral matter together and makes the bones tough and somewhat elastic. The fire burned out the animal matter of the first bone, and the acid dissolved out the mineral matter of the second bone. *The mineral matter is chiefly lime, and makes up about two thirds of the weight of the bone.* The animal gelatine is a gristly substance. As the body grows old, the animal matter of the

bones decreases, and they become lighter. They are more easily broken and do not heal so readily as the bones of young persons.

The skeleton is subdivided into the bones of the *head, trunk, and limbs*. The bones of the trunk consist of the spine and of the chest, the shoulder blades, collar bone, tongue bone, and hip bones.

The **spinal or vertebral column** is made up of twenty-six bones (Figs. 38, 39). It is the axis of the human skeleton to which all other bones are directly or indirectly attached. All animals with inside skeletons have this column, and are called vertebrates. Fish, reptiles, birds, beasts, apes, and man are vertebrates. The spine, as this column is sometimes called, is not only the main connecting structure and support of the body, but it forms a channel through which passes the spinal

FIG. 38. — VERTEBRAL COLUMN.
Rear view.



FIG. 39. — VERTEBRAL COLUMN.
Side view.

cord. Figure 40 shows a vertebra, or one of the bones that compose the column. The *projecting points* are for

the attachment of ligaments and muscles. The *main body* of each vertebra is for supporting the weight transmitted by the column above. Just behind this thick body

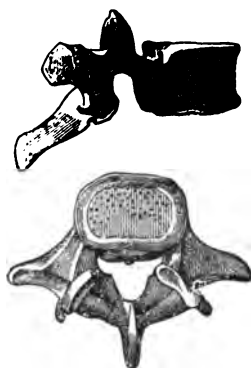


FIG. 40. — SIDE AND UNDER VIEW OF A VERTEBRA.

is a *half ring* (Fig. 40), which, with the half rings on the other vertebræ, form the canal for the spinal cord. Between the vertebræ are thick pads of gristle, or cartilage, which act as cushions to prevent jars, and by compression allow bending of the spinal column in all directions.

The Chest (see Fig. 97). — The twelve pairs of ribs are attached to the spinal column behind, and extend around toward the front of the body, somewhat like hoops. The first seven pairs, called *true ribs*, are attached directly to the breastbone.

Each of the next three pairs, called *false ribs*, are attached to the pair above it. The last two pairs, called *floating ribs*, are free in front.

The tongue bone (see colored FIG. 91) is readily felt in the neck. Many muscles are attached to it, the chief one being the tongue. This bone is one of the few bones in the body that is not attached to any other bone. It is shaped like the capital letter U, is felt to be somewhat rough, and can be moved from side to side with the hand.

The collar bones (Fig. 33) can be traced from the shoulders until they nearly meet on the breastbone at the top of the chest. The collar bone is shaped like the Italic letter *f*, and serves to hold the shoulder out from the chest that the motions of the arm may be free.

The flat, triangular **shoulder blade** (Fig. 41) can be felt by reaching with the right hand over the left shoulder. It spreads over the ribs like a fan. Its edges can be made

out, especially if the shoulder is moved while it is being felt. The high ridge which runs across the bone can be felt extending to the top of the shoulder.

The edges of the **hip bones** can be felt at the sides of the hips (Fig. 42). The hip bones, with the base of the spine, form a kind of basin called the *pelvis*.

The **skull** (Fig. 43) rocks, or nods, on the top vertebra. It consists of the cranium, or brain case, and the bones of the face. The shapes and names of the bones of the skull are shown in Figure 43. The cranium appears to the touch to be smooth and round, with no sign of the joints that unite



FIG. 41.—
LEFT SHOULDER
BLADE, seen from
behind.

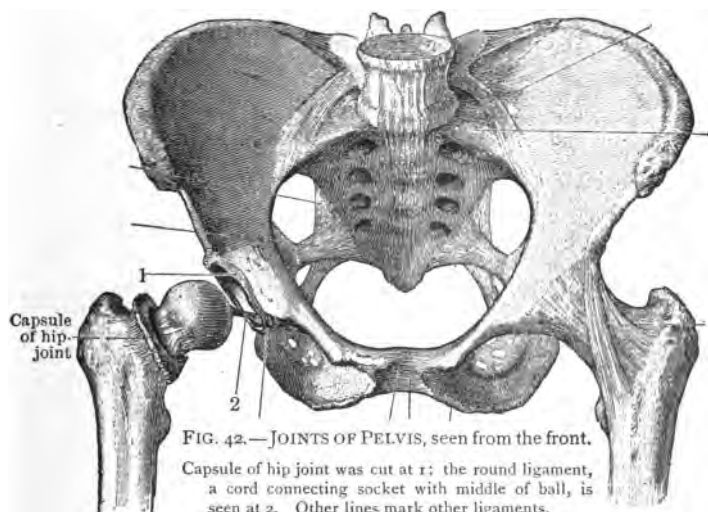


FIG. 42.—JOINTS OF PELVIS, seen from the front.

Capsule of hip joint was cut at 1; the round ligament, a cord connecting socket with middle of ball, is seen at 2. Other lines mark other ligaments.

its eight bones. Most of the bones of the face can be traced by feeling them. The *lower jawbone* is distinct; the two upper jawbones meet just beneath the nose;

the *cheek bones* stand out prominently in the cheeks. The two narrow *nasal bones* form the ridge of the nose for

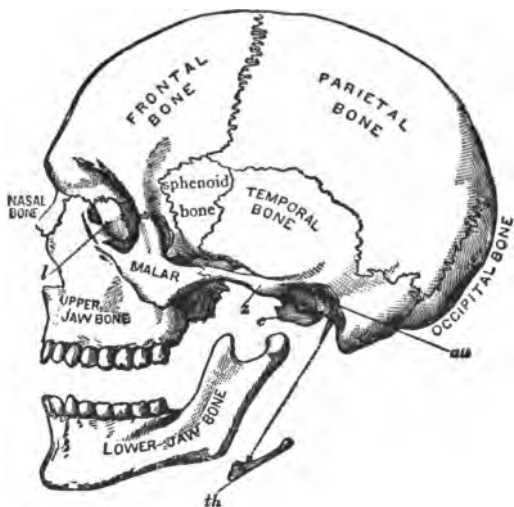


FIG. 43.—SIDE VIEW OF SKULL.

The bones of the cranium, or brain case, are broad and flat; the bones of the face are irregular. *th*, hyoid bone.

half its length, the lower part of its ridge being cartilage; for the nose is so prominent that if it were not flexible it would often be broken.

The **arms and legs** have bones that closely correspond to each other. The Latin names of these bones, as well as of all the other bones, are given in Figure 33.

There are 30 bones in each arm and 30 in each leg. Here is a list of the bones of the arm, followed by the names in brackets of the corresponding leg bones: upper arm bone [thigh bone], 2 forearm bones [shin bone and splint bone], 8 wrist bones [7 ankle bones], 5 palm bones [5 bones of instep], 14 finger bones [14 toe bones]. The shin bone is the larger bone between knee and ankle. Its lower end can be felt as a bump at the ankle. The long, slender splint bone and the shin bone are bound side by side.

Differences between Arm and Leg.—There is a saucer-like bone, called the *kneecap*, embedded in the large ligament which passes over each knee. There is no such bone in the elbow. There is one less bone in the ankle than in the wrist, hence there are the same number of

bones in the arm and leg. The shoulder joint is more freely movable than the hip joint. The fingers are longer and more movable than the toes; the thumb moves far more freely than the big toe. The instep is much stronger than the palm; for each instep must support, unaided, the weight of the whole body at each step, with any other weight that the person may be carrying. The palm is nearly flat, but the instep is arched to prevent jars (Fig. 47). When the weight of the body is thrown on the foot at each step, the top of the arch is pressed downward, making the foot longer than before. The arch springs up when the weight is removed.

THOUGHT QUESTIONS. — The Shapes of Bones. Write *L*, *F*, or *I* after these names (see Figs. 36, 47), according as the bones are long, flat, or irregular: face, skull, vertebra, hip, rib, breastbone, collar bone, shoulder blade, upper arm bone, lower arm bones, wrist, palm, fingers, thigh bone, shin bone, splint bone, ankle, instep, toes, kneecap, tongue bone.

Joints. — The meeting of two bones forms a joint. Some of the joints are immovable. The skull bones join in zigzag lines called *sutures*, formed by the interlocking of sawlike projections (Fig. 44). These *immovable* joints are necessary for the protection of the brain, which is the most delicate of the organs. The brain attains almost its full size by the seventh year of life, and its bony case need grow very little after that. The joints of the pelvis are also immovable. All *movable joints have two cartilages*, and as the bones turn, one cartilage slips over the other. There is an intermediate class of joints found between the vertebræ and where the ribs join the breastbone. These

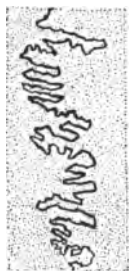


FIG. 44. — SUTURES OF SKULL.

joints depend for their motion upon the flexibility and compressibility of their cartilages. They are called mixed, or *elastic*, joints, and allow slight motion. *Such a joint has only one cartilage.*

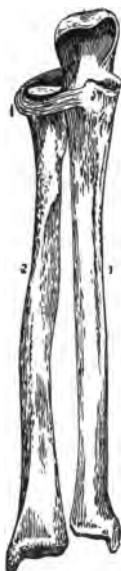


FIG. 45. — BONES OF FOREARM.

A ligament holds the head of the radius in place while it rotates.

Kinds of Movable Joints.—The movable joints are found chiefly in the limbs. When one end of the bone is rounded and fits into a cuplike hollow, the joint allows motion in all directions, and is known as a *ball-and-socket* joint. The hip joints and shoulder joints are examples. A *hinge-joint* allows motion in only two (opposite) directions; for example, the to-and-fro motion of the elbow. A *pivot* joint allows a rotary motion; examples: the first vertebra on the second, one bone of forearm upon the other (see Figs. 45 and 35).

Why the Long Bones are enlarged at the Joints.—You learned that the ends of the long bones are enlarged, and of spongy structure.

This structure adds to the elasticity of the bone and lessens jars. The enlargement at the joints, by raising the tendons away from the limb, brings them at an angle to the bone, and thus gives them more effect in bending the limb than they would have if parallel to the bone. When a fisherman wishes to lift his rod, he does not pull toward the end of the rod, but at an angle to the rod.

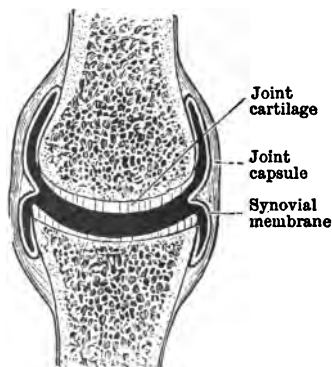


FIG. 46. — DIAGRAM OF A JOINT.

The Four Features presented by a Movable Joint (Fig. 46). — If not held in place, the bones would slip out of their sockets, hence there are *ligaments*, or tough bands, to bind the bones together. Sudden jolts would jar the bones and injure them; shocks are prevented by a layer of elastic *cartilage* over the end of each bone. The moving of one bone over another in bending a joint would wear the bone with friction unless the cartilages were very smooth and lubricated with a fluid called the *synovial fluid*. The synovial fluid would be constantly escaping into the surrounding tissues except for the collarlike ligament called the *capsule*, which surrounds the joint and is attached to each bone entirely around the joint (Fig. 42).

THOUGHT QUESTIONS. — The Kinds of Joints. Write *B, H, G, E, or I* after these names according to the kind of joint (ball-and-socket, hinge, gliding, elastic, immovable): between bones of skull, head nodding, head turning, vertebræ, lower jaw, ribs to breast-bone (Fig. 97), shoulder, elbow, wrist, fingers, hip, knee, ankle, toes.

Growth of Bones. — The blood vessels pass into the bones from the periosteum. *If the periosteum is removed, the larger blood vessels are taken away and the bone beneath it perishes.* If the underlying bone is removed and the periosteum left, the bone will be replaced. A curious proof of the active circulation in the bone is furnished when madder is mixed with the food of pigs. In a few hours the bones become a darker pink than usual; and if the madder is fed to the pigs for a few days, their bones become red. A child grows in height chiefly during three or four months in spring and summer; but the body broadens and becomes heavier during autumn.

Health of the Bones. — It is plain that *a strong and free circulation of pure blood contributes to the health and*

strength of the bones; good food and pure air make pure blood. Impure food and injurious substances, like *alcohol, tobacco, and opium, weaken the bones if they are taken into the blood.* Cases of "delayed union," or slow mending of broken bones, occur more often with intemperate than with sober people. This is because the vitality of the bone cells has been weakened by the alcohol. Why do surgeons dislike to operate on an old drunkard?



FIG. 47.—SIDE VIEW OF SKELETON.

Deformities. — A bone may be sound, yet deformed; *no human body can be perfect in function if any part of its framework is deformed.* These deformities may come in various ways, and the remainder of this chapter will be devoted to this topic.

Constant pressure in one direction is the usual cause of deformed bodies. This pressure may result from: (1) the weight of the body held in *wrong positions*; (2) confining the body by bands or *tight clothing*; (3) unequal development of muscles from work which brings *certain muscles constantly into use*, and leaving largely unused the muscles that would restore the balance.

Posterior Curvature of the Spine. — The spine (see Figs. 39, 47) has two backward curves (opposite chest and hips) and two forward curves (at loins and neck). The

deformity called posterior curvature is chiefly an exaggeration of the upper posterior curve. Round shoulders is the slightest, and hunch-back the most marked, degree of this deformity. Causes: 1, *Bending over the work* while either standing or sitting; 2, *slipping down in the seat*, as in Figure 62; 3, working habitually with the *work low in front*, as reading and writing at too low a desk (Fig. 60), or bending over while hoeing; 4, *weak muscles* in the back; 5, wearing shoes with *high heels*; 6, binding the ribs down with *tight clothing*; 7, walking with the *head drooped forward* or the chest flat. This deformity is brought about by *stretching the ligaments* at the back side of the spine, and by *compressing the cartilages until they become wedge-shaped*, with the thin part of the wedge in front. The flexibility of the spine is a great advantage, but it increases the risk of deformity. One of the most serious evils of posterior curvature is a flat chest and restricted breathing.

Lateral Curvature of the Spine. — A perfect spine curves to neither side (see Fig. 59), but is perfectly erect. The least habitual lateral curvature is deformity. Causes: 1, writing at a *desk that is too high*; 2, habitually carrying a book satchel or other *weight in the same hand*; 3, riding horseback with a *side saddle*; 4, carrying the *head to one side* (Fig. 58, Plate II).

FIG. 48. — Incorrect posture.

FIG. 49. — Correct, but strained and stiff. Compare position of head, chest, and hips in Figs. 48, 49 with the vertical line.



FIG. 48.



FIG. 49.

THOUGHT QUESTIONS. — **The Skeleton.** 1. Which part of a vertebra (Fig. 50) serves chiefly for support? For attachment of muscles?



FIG. 50. — A VERTEBRA.

For protecting spinal cord? 2. Why is it well for the spine to have many instead of a few joints? 3. Find by bending your own body, or by studying Figure 39, which part of the spine allows least motion. Why? 4. Which part of spinal column is most easily sprained? Which next?

5. Why is energy saved by having a pivot joint at the elbow rather than at the shoulder? 6. Why is it better to have ball-and-socket joint at shoulder, and hinge joint at elbow, rather than the reverse?

Tests for Lateral and Posterior Curvature. — A strip may be fastened with one nail upon a post at a height of six or eight feet. The end may be turned down until it just touches the shoulder. Turn and bring the other shoulder under the strip; if the shoulders are the same height, the spine is straight. If they are of unequal heights, the spine should be examined to see whether it forms a perfect vertical line (see Fig. 59). To test for posterior curvature, stand facing the wall, with the chest touching the wall, and having the head in its usual position. If there is no deformity, the face will not touch the wall.

To overcome Spinal Deformities. — The work, or the manner of doing the work, should be so changed as to *give extra labor to the neglected muscles*. Avoid the habits mentioned above as causing deformity. Sit and stand in the manner described in the next paragraph. Sleeping on the back upon a hard mattress without a pillow tends to cure posterior curvature and flat chest.

The **correct position** in standing is: *chest forward, chin in, hips back* (Figs. 48, 49). To sit correctly, *sit far back in the chair* (Figs. 60, 61, 62) with the body erect and balanced. In youth the bones are soft and growing; they will readily grow into perfect shape, and will almost as readily grow deformed.

PRACTICAL QUESTIONS. — The Skeleton. 1. What kind of a chair back causes one to slide forward in the seat? 2. What fault in sitting is made necessary by using a chair with so large a seat that the front edge strikes the occupant behind the knee? 3. Why is the shoulder more often dislocated than the hip? 4. High pillows may cause what deformity? 5. Find three bones in the body not attached to other bones. Find twenty-five bones attached to other bones by one end only (Figs. 33 and 47). 6. What deformities may result from urging a young child to stand or walk? 7. Which bone is most often broken by falling upon the shoulder? 8. Where in bones is fat stored for future use? 9. Ligaments grow very slowly. Why is the recovery from a sprain often tedious? 10. How many of your classmates habitually slide forward while sitting? Count and report. 11. When the school is marching out, count those who walk with head protruded (Fig. 48). Report.

REVIEW QUESTIONS. — Chapter I. 1. Write the names of the following animals in a list according to the degree in which they resemble man, and give the reason for the order: horse, crawfish, bird, ameba, dog. 2. Describe the ameba, and tell how it moves, eats, breathes, and multiplies. 3. What in man's body resembles the ameba? 4. How is a cut in the flesh repaired? 5. Of what does a living cell chiefly consist? What is always found in the cell? What usually surrounds it? 6. Define cell; fiber; tissue; membrane. 7. Compare the cell community with a community of people. 8. What kind of cell in the human body corresponds to a railroad man; a farmer; a soldier; a Jack-at-all-trades; an official or teacher? 9. Show the advantage of division of labor.

1. Define anatomy; physiology; hygiene; organ; function. 2. Name the three kingdoms into which all material things are divided. 3. Define organic; inorganic. 4. State the chief difference between animals and plants. 5. Why must there be different tissues in the body? 6. Into what two general classes are the seven tissues divided, and why? 7. Name the two master tissues. What is their work? 8. How long are the longest branches of the nerve cells? 9. Define nerve; motor fibers; sensory fibers. 10. Name the five supporting tissues. 11. What are the two kinds of fibers in connective tissue? 12. State a fact which shows the great abundance of connective tissue. 13. From what tissue is fatty tissue developed? How? 14. Of what does epithelial tissue consist? Where is it found? How is it nourished? 15. What is the purpose of each of the two classes of epithelial cells? 16. What is the structure of cartilaginous tissue? What are the two varieties of it? 17. What is found in the larger canals

of osseous tissue; the smallest canals; the minute cavities? **18.** What is oxidation? **19.** Name six poisons.

Chapter II. **1.** What is the chief function of the skin? **2.** What is the structure of the dermis and epidermis? What and where are the papillæ? **3.** Describe the cells of the epidermis near the surface; the deeper cells; the lowest cells. What are albinos? **4.** From what does a hair grow? **5.** Explain gray hair; baldness; hair standing on end. **6.** From what does the nail grow? How fast does it grow? **7.** Into what do the oil glands generally empty? **8.** What is the use of the oil? Describe a sweat gland. **9.** What does perspiration contain? How is the amount of perspiration controlled? **10.** What is the anatomy of freckles; warts; moles; scars; proud flesh; pimples; black heads? **11.** What are the uses of the muscles in the skin? Of the nerves? **12.** What are hot spots; cold spots? (Fig. 162.) **13.** How does the skin help to regulate the heat of the body? **14.** What information does the feeling that we are hot or cold give us? **15.** How does alcohol affect the feeling of warmth?

1. Discuss the effects upon the skin of outdoor and indoor life. **2.** Show the need of training the skin. **3.** What are the characteristics of a vigorous skin? **4.** Show why it is necessary to counteract the effects of civilized life upon the skin. **5.** State the benefit of a warm bath and the time and manner of taking it. **6.** State the benefits of cold baths. **7.** How may one become used to them? **8.** Discuss the relation of material (cotton, linen, woolen), color (dark, light), and texture (tight, loose) of clothing to climate and weather.

Chapter III. **1.** Study by observation your arm and hand, and state all that you have learned about it. **2.** What deposits the lime in the bones? **3.** Why is a skeleton needed? **4.** Name the three forms and the three uses of bones. **5.** Describe all that can be seen in a long bone sawed lengthwise. **6.** Describe experiments on the composition of bones. **7.** How is the skeleton subdivided? **8.** State the parts of a vertebra and the use of each part. **9.** What are the attachments of the twenty-four ribs? **10.** Describe and locate the tongue bone; the collar bone; the shoulder blade; the hip bone; the cranium. Compare the bones of the arm and leg. **11.** State name and description and give example of each kind of joint. **12.** Why is periosteum necessary for the growth of the bone? **13.** What is most necessary for the health of the bones? **14.** Give several sources of pressure that may deform the bones. **15.** Give seven causes of posterior curvature of the spine. Give four causes of lateral curvature. **16.** Describe the correct position in standing; in sitting. **17.** Locate: scapula, sternum, patella, tarsus (see Figs. 33, 47).

CHAPTER IV

THE MUSCLES

Uses of Muscles. — The bones give the body its general proportions ; the muscles give its graceful curves. Every muscle is a living machine ; a bone is a lever for a muscle or group of muscles to set in motion. The muscles weigh more by far than any other set of organs in the body ; they constitute forty-one per cent, or almost half, of the bodily weight. The use of the muscles is to obtain and prepare the food which the body needs. They are necessary in chewing, swallowing, and in digesting the food ; in making the blood circulate, in breathing, in every change in the expression of the face, and in every variation in the tone of voice. When no motion whatever can be discovered in the body, we know it is dead. You learned while studying the bones of the arm that there are at least two muscles attached to a bone to move it in opposite directions. Since there are two hundred and six bones, you are not surprised to learn that to move the bones and accomplish the various purposes just stated, there are about five hundred muscles.

Two Kinds of Muscles. — All muscles are controlled by means of the nervous system. Some of them are directed by parts of the brain that work consciously ; others are controlled by the spinal cord and the parts of the brain that work unconsciously. Those of the first kind are *usually controlled by the will*. Although they sometimes

act involuntarily, *they are called voluntary muscles*. Those of the other kind are *never controlled by the will, and are called involuntary muscles*. We cannot cause them to act, nor can we prevent them from acting. They contract more slowly than the voluntary muscles.

Structure of Voluntary Muscles. — A beefsteak is seen to be chiefly red, although parts of it are white or yellowish.

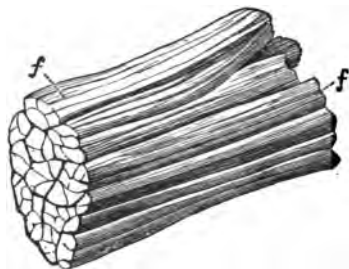


FIG. 51. — MUSCLE BUNDLE bound together by connective tissue sheaths.

The white or yellowish flesh is fat ; the red, lean flesh is voluntary muscle. If a piece of beef is thoroughly boiled, it may be easily separated into *bundles the size of large cords*. These bundles may, by the use of needles, be picked apart and separated into *threadlike fibers*. These,

under a magnifying glass, may be separated into *fine strands called fibrils*. These last are the true muscle cells ; they are shown by the microscope to be crossed by many dark lines (see colored Fig. 12). Hence *voluntary muscles are called striated or striped muscles*. Prolonged boiling and patient picking with a needle are needed to dissect muscle, because the bundles are held together by thin, glistening sheets of connective tissue by which they are surrounded. This

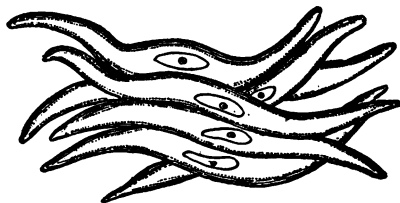


FIG. 52. — INVOLUNTARY MUSCLE CELLS (or fibers).

connective tissue surrounds and holds in place the separate fibers of each bundle. The voluntary muscles move the bones, and are located in the limbs and near the surface

of the trunk; the involuntary muscles are chiefly in the cavity of the trunk.

Structure of Involuntary Muscles. —

The fibrils of these muscles are *spindle-shaped* (see Fig. 52). There are no cross lines on the fibrils, and involuntary muscles are called *smooth or unstriped muscles*. The involuntary muscles *belong to the internal organs*, and relieve the will of the responsibility and trouble of the activity of these organs; otherwise, the mind would have no time for voluntary actions.

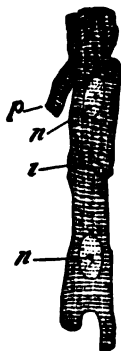


FIG. 53. — TWO MUSCLE FIBERS OF HEART.

THOUGHT QUESTIONS. — **Classification of Some of the Muscles.** Mark *I* for involuntary and *V* for voluntary after the appropriate muscles in the following list: —

Muscles for chewing. Muscles for swallowing. Muscles of the heart. Muscles that move arms. Muscles for breathing. Muscles in the skin that cause the hair to stand on end. Muscles that move eyelids. Muscles that contract pupil of eye. Muscles for talking. Muscles that contract and expand the arteries (in blushing and turning pale). Muscles that move eyeball. Muscles that give expression to the face.

Tendons. — *The connective tissue which binds the fibers of muscles into bundles, and forms sheaths for the bundles, extends beyond the ends of the muscles and unites to form tough, inelastic white cords called tendons.* Some muscles are without tendons, and are attached directly to bones. Study the figures and find examples of this (see Figs. 63, 64). To realize the toughness of tendons, feel the tendons under the bent knee or elbow where they feel almost as hard as wires. *The tendons save space* in places where there is not room enough for the muscles, and permit the bulky muscles to be located where they are

out of the way. Wherever the tendons would rise out of position when a joint is bent, as at the wrist and ankle, they are bound down by a ligament (Figs. 67, 69, Chart).

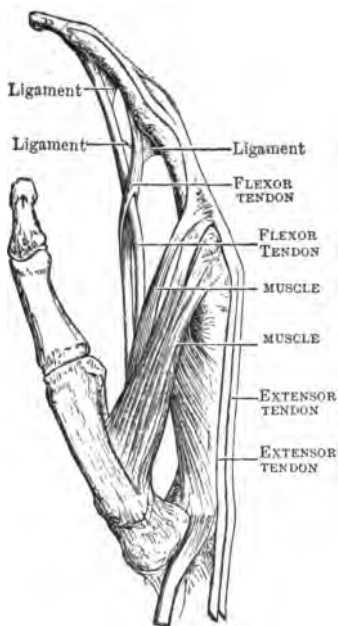


FIG. 54.—TENDONS OF INDEX FINGER.

and eyes. Attached to the circular muscle of the mouth are little muscles running off to various parts of the bones and skin of the face (see Chart of the Muscles). The facial muscles are called *muscles of expression*. Some draw the corners of the mouth down, others draw them up, and others widen the mouth as in smiling.

There are large muscles in the *calf of the leg* that raise the heel and cause the person to stand upon

Some of the Important Muscles.—The *gullet* is a fleshy tube of involuntary muscle; successive rings of muscle contract during the act of swallowing. It is the swiftest in action of all the involuntary muscles. The muscular walls of the stomach and intestines contract in waves that follow one another along the food tube. This is called *peristalsis*.

Some muscles are *hollow*, as the heart. *Circular* muscles, called *sphincter muscles*, are found around the mouth

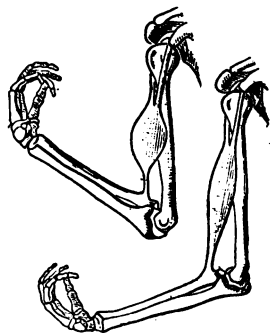


FIG. 55.—For blackboard. BICEPS relaxed and contracted.

the toes (see Fig. 71). It is attached to the heel by the largest tendon in the body. The cavity of the trunk is divided into the chest and abdomen by the broadest muscle in the body; it is called the *diaphragm*, and is the most important of the breathing muscles. The longest muscle in the body is called the *tailor's muscle*; it is used in crossing the legs (see Fig. 68, Chart). Muscles like the tailor's muscle, that go around a limb, twist or rotate the limb when they contract. Muscles that extend straight along the limb either bend it and are called *flexors*, or straighten it and are called *extensors*. Many of the muscles are arranged in pairs and cause motion in opposite directions; they are said to be *antagonists*. The action of the biceps has been described. Its antagonist is the triceps on the back of the arm (Fig. 67, Chart).

THOUGHT QUESTIONS. — Voluntary Muscles. Locate the muscles having the functions named in the following list. Locate them by performing the action and feeling the muscle with your hand. Be ready to point them out on the Chart of the Muscles. Locate the muscle (or muscles) that:—

1. Lifts the whole arm outward and upward.
2. Draws it downward and forward.
3. Draws it downward and backward.
4. Bends the elbow.
5. Straightens the elbow.
6. Bends the fingers.
7. Straightens the fingers.
8. Turns the head.
9. Draws the shoulders back.
10. Bends the knee.
11. Straightens the knee.
12. Raises the toes.
13. Raises the body on the toes.
14. Crosses the legs.

How the Muscles grow Stronger.—Nature has provided that any part of the body shall receive more blood when it is working than when it is resting. *When it works the hardest, the blood tubes expand the most, and its blood supply is greatest.* So whenever a muscle is used a great deal, an unusual amount of material is carried to it by the blood, the cells enlarge and multiply, and the muscle

grows. The walls of the capillaries are so thin that the food which is in the blood readily passes from them to the muscle. Because of the oxidation taking place, a working muscle is warmer than one at rest. *By use a muscle grows large, firm, and of a darker red*; by disuse, it becomes small, flabby, and pale.

Muscles can be developed much more completely in *youth* while the body is growing than later, and they retain the development longer. Yet even after we are grown the muscle fibers sometimes multiply enormously. In youth the body can be readily stunted by tasks too heavy for children, as those in a factory or a mine, or on a farm. Muscles that are strained or that are used so much that they wear out faster than they can be fed by the blood, will diminish in size instead of grow.

Why the Muscles work in Harmony.— There are about five hundred muscles, yet the body is capable of many thousands of different motions. This is because of various combinations in using the muscles. Some acts require a great number of muscles. *When a boy throws a stone, almost every part of the body is concerned in the action.* His arm, his legs, his eyes, the breathing, the beating of the heart, are all modified to assist in the effort. How is it brought about that they all act at the same time and in perfect harmony? This occurs because all the muscles are connected with the brain by nerves. When the boy wills to throw the stone, nerve impulses are sent to all the organs that can assist, and they are excited to just the amount of action needed. Of course, *long practice is needed to train the nerves and muscles for any complicated action.* Walking requires the action of dozens of muscles, and it is not strange that many months are required in learning to walk well.

The Nerve Impulse and the Contraction. — Each nerve that goes to a muscle is composed of many fibers; the fibers soon separate and go to all parts of the muscle, and *each muscle fiber receives its nerve fiber* (see Fig. 56). The muscles never contract of their own accord, any more than a telephone bell rings of its accord. The brain sends nerve impulses to the muscles, each fiber is stimulated at once, and all the fibers shorten and thicken together, causing the shortening and thickening that is so readily noticed in the whole muscle. This change is spoken of as contraction; but since the muscle does not become smaller, the word may be misleading. When the muscle shortens, it thickens in proportion and occupies as much space as it did when relaxed.

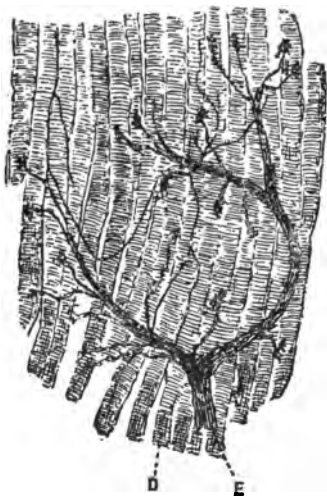


FIG. 56.—MOTOR NERVE FIBERS ending among fibers of voluntary muscle.

Where does Muscular Energy come from? — In the ringing of an electric bell, the wire takes the electric energy from the battery to the bell; and the battery, not the bell, furnishes the energy which moves the clapper. *The nerve does not furnish the energy which the muscle uses when contracting. The muscle cells have already stored up energy from the food and oxygen brought to them by the blood.* Similarly, when a gun is fired, the energy was already stored in the cartridge and was only set free by pulling the trigger.

How a Muscle stays Contracted. — The muscle relaxes at

once after contraction ; and in order to keep it contracted, impulses must be sent in quick succession, causing in fact many contractions ; the effect of this is sometimes visible, as the trembling of the muscle.

Muscular Tone. — Relaxation is the usual condition of a muscle, yet *a healthy muscle even when relaxed is always exerting a slight pull upon the bones.* This state of slight tension is called muscular tone. It is necessary in order to keep the muscles prepared for promptness and steadiness of movement. This tone causes a sleeping person to assume a slightly flexed position ; it causes cuts in the flesh to gap open ; it causes the muscles to pull a dislocated arm or leg beyond the socket, so that considerable force is necessary to get it into position to slip into its socket again. To keep muscles in this condition slight nerve currents are being continually sent to them.

What causes Fatigue. — Fatigue or exhaustion is due to the production of *certain poisonous waste products*, which result from the activity of the muscles, and which have the effect of paralyzing the nerves in the muscles. If the worker rests for a time, the blood will take away these waste products ; and the impulses sent along the nerves will easily cause the muscle to work again. Can you explain why it is less fatiguing to walk for an hour than to stand perfectly still for ten minutes ?

How the Activity of One Muscle may make Another Muscle Tired. — The fatigue poisons sent into the blood current by a few muscles working for a long time, may be distributed all over the body, and fatigue reaches not only the other muscles, but the brain also, so that rest and sleep become imperative. Runners have been known to drop dead after long running. Horses have died suddenly from

overexertion. Muscular exertion strengthens the lungs and skin by arousing them to their most powerful activity, that they may free the body of the waste products.

A grave danger from athletics is that of developing the muscles, including the heart, to an enormous extent, by training; then *when training ceases the muscles undergo fatty degeneration from disuse*. Heart disease and other troubles may follow. Most athletes die young, killed by trying to turn their bodies into mere machines for running, boxing, rowing, instead of living complete lives. In physical culture, it is necessary to develop lungs, nerves, etc., equally with the muscles; but it is also dangerous to develop immense lungs and suddenly to cease activities that call them into use. Portions of the lung tissue may then shrink together and become diseased. Abrupt changes of habits are dangerous to the health. *A more common cause of fatty degeneration of the muscles is alcohol*, taken in the form of beer and other drinks.

THOUGHT QUESTIONS. — The Work of Muscles. 1. By studying the Chart of the Muscles, apply these four pairs of adjectives in their proper places in the lines below: long and round; thin and flat; short and narrow; broad and flat:—

The muscles of the face are — and —.

The muscles of the cranium are — and —.

The muscles of the trunk are — and —.

The muscles of the limbs are — and —.

2. Span the biceps, holding tip of finger in elbow and thumb farther up the arm. How many inches of its length does the biceps lose by contracting? 3. Why is round steak usually the toughest steak? The most nutritious? 4. Why is a fowl's leg dark meat, although its breast and wing are white meat? Why is a fowl's breast white and a dove's breast dark? (Page 58, line 5.) 5. Which muscles must be strengthened to overcome round shoulders and posterior curvature of the spine? 6. The muscles that move the fingers and wrist are in the —; the muscles that move the forearm are in the —; the muscles that move the upper arm are in the — (see Chart of Muscles).

How Muscular Activity helps the Health.—Life is change, stagnation is death. *Muscular activity uses up the food, gives a good appetite, and sets the digestive organs to work; it uses up the oxygen and sets the lungs to work; but most of all, every contraction of a muscle helps the blood to flow.* As a muscle contracts, it presses upon the veins and lymphatics, and, by this pressure, forces the blood and lymph along. In any ordinary activity, dozens of muscles are being used. That the effect upon the circulation is very powerful, is shown by the rosy skin, deep breathing, and rapid heart beat. The many benefits of an active circulation of the blood and lymph will be discussed in the next chapter.

Advantages of Work and Play over Gymnastic Exercises.—Lord Rosse of Ireland, during the famine of 1847, fed a great number of people who were out of work. To save the self-respect of the men and prevent their forming habits of idleness, he caused a number of them to dig holes, and another set of men to fill them up. When each set of men learned what the other men were doing, they refused to continue in such useless labor. The interest that comes from doing something useful, makes exercise doubly beneficial to the health. The lifting of dumb-bells, Indian clubs, and pulley weights, and letting them down again, tends to become very irksome, even though done with the knowledge that the exercise will benefit the health. *Useful labor and games place definite objects in view and do not require so great an effort of the will nor exhaust the nerves so much as mere exercise.* The interest in the work or the game serves to arouse all the nerves and muscles to work in harmony.

An Advantage of Gymnastics over Work and Play.—Gymnastics can furnish any required variety of exercises

and can develop exactly the muscles that need development and leave those idle that have become overdeveloped by doing constantly one kind of work or playing continually the same game. The deformity of a flat chest (and round shoulders which always accompany it) does not so often indicate a weak chest or small lungs as it indicates weak or relaxed muscles of the back and the habit of sitting in a relaxed position at work. Such a person may have large lungs, but he is in the habit of carrying them too far behind. The deformity may result from constantly studying or reading, keeping accounts, or rowing a boat. But the condition is nearly as common among farmers as among students and business men, because many of them think they have to stoop over while plowing or hoeing, or while riding on a wagon seat without a back. The chest can be held up even while hoeing. Round shoulders not only give an awkward appearance, but invite disease of the lungs. To overcome this deformity, special exercise for strengthening the muscles of the back should be taken. Chopping wood with a light ax strengthens the muscles that draw the shoulders down, as the strength is exerted in striking the blow. Using a heavy ax stretches the muscles that lift and draw back the shoulders, as the strength is exerted chiefly while lifting the ax. *Gymnastic exercise is not wholly an artificial custom.* Cats stretch themselves, stretching each leg in succession; many animals gambol and play. A gymnastic drill in school, taken to music and with large numbers of pupils in the drill is interesting as work or play, and should not be neglected for any study, however important.

Heredity.—A well-developed man of one hundred and fifty pounds weight should have sixty pounds of muscles. The proportion is often different in the puny bodies of the

average civilized man, such as clerks, merchants, lawyers, and other men with sedentary occupations ; their bodies are as likely to be lean and scrawny or fat and flabby as to be correctly proportioned. Why does a natural man have sixty pounds of muscles instead of twenty pounds of puny strings such as would have sufficed for a clerk, student, or a writer? This is because, in his native condition, he had to seek his food by roaming through the forest, contending with wild beasts or with other savage men, often traveling many miles a day, climbing trees, etc.

Attempting an Impossibility. — *It is impossible for the human body to change greatly in a few hundred years.* The body of man served him for many ages for the manner of life outlined above. It was suited for these conditions, and the muscles and the organs that support them cannot accommodate themselves to changed conditions in a few generations. It has only been a few hundred years since the ancestors of the Britons and Germans, for instance, were running wild in the German forests, clad in the skins of wild beasts. Yet *civilized man lets his muscles fall into disuse*, he takes a trolley car or horse vehicle to go half a mile, an elevator to climb to the height of thirty feet. He neglects all his muscles except those that move the tongue and the fingers of the right hand. He never makes enough exertion to cause him to draw a deep breath, and his lungs contract and shrivel. He seldom looks at anything farther than a few inches from his nose, and his eyes become weak. At the same time that he neglects his muscles and his lungs, he overworks his brain and his stomach ; yet he expects his body to undergo the rapid changes to suit the demands of his life. Such rapid changes in the human race are impossible.

Health and Modern Life. — It has been said that one third of the maladies with which human beings are afflicted are the result of *too much eating*, another third of *too little muscular work*, while all the other causes of ill health combined are necessary to produce the remaining one third. It is estimated that there are twenty-seven million cases of sickness in the United States annually, and of these one million are chronic invalids.

Common Sense and Health. — The average man who finds himself sick does not appeal to common sense and the science of hygiene, but to a mysterious, nauseating, or stimulating drug, or a bowel-convulsing mineral spring. He may get *temporary relief* in some way, then he returns to his usual routine and *goes on making himself sick again by his bad habits*. This man would not feed his overworked horse tonics and stimulants in order to get more work out of him, nor would he expect to improve the health of the animal by the purchase of a new whip. Yet the tonics and alcoholic drinks used by man are no better than a whip; *they get strength out of instead of putting strength into him*. A man who owns a sick horse changes the manner of using him, or turns him out to pasture. *An invalid man must likewise make radical changes in his manner of living*. He should return to simple, natural food such as his ancestors ate, use his brain less, his muscles more, and live more in the fresh air. He must cease to cultivate sickness and begin to cultivate health.

Care of Health a Duty. — A man in a large city purchased a beautiful horse and rode him daily in the parks and streets. Soon his business took all his time, and he seldom rode. The horse stamped impatiently in his stall. When his friends said he should not treat the horse so, he began to take daily rides again; but soon concluded that

it was time to sell the horse, if he had to devote himself to the comfort and health of the horse. The man is now fat, limping, and rheumatic. This incident is related to illustrate how a man will sometimes take better care of a horse's health than of his own. The rides would have been as good for him as for the horse.

Many people say they cannot afford to take care of their health. They say their duty to others requires them to neglect themselves. A man who was bookkeeper in a bank at a salary of two hundred dollars a month was taken with a chronic cough. His friends said he must take a few months' vacation and become strong again. He replied that his duty to his family forbade it; some of his daughters were just grown and needed to dress well in society. Within a year he died, and his daughters had to work for a living, one working as a seamstress, another as a clerk in a dry-goods store. Our duty to others requires that, first of all, we take care of our bodies.

Many men have by overwork made fortunes of millions of dollars, and have afterward spent immense sums for treatment and traveled over the world seeking to regain health, but failed to find it. One of the richest men in America ate hardly anything more than a little parched toast for years before he died. Another has lost all the hair on his head from indigestion, and his wife will not trust any one to prepare food for him but herself. Unless he chops wood or takes other exercise every day, every morsel of food he eats is a torture to him. A man that does not see that *sound health is the most valuable thing in the world, except a clear conscience*, is in danger both of wrecking his own happiness *and of failing in his duty to others*.

THOUGHT QUESTIONS. — **Shoes.** 1. What the faults of shoes may be in size; shape; sole; heel; toe; instep. 2. Name deformities re-

sulting to skin of foot ; nails ; joints ; arch ; ankle ; spine. **3.** State effects of uncomfortable shoes on muscular activity ; mind and disposition. **4.** State effect of aversion to walking, on muscles ; circulation. **5.** If a shoe is too loose, it slips up and down at the heel and chafes the skin there ; if too tight, there is pressure on the toes, which causes a corn or ingrowing nail. Have your shoes been correct, or have they been too loose or too tight? According to this test, what proportion of people wear shoes that are too tight?



FIG. 57. — ARCH OF FOOT.

6. How many sprained ankles have you known among boys ; girls? **7.** Why is it that people who grow up in warm climates have high, arched insteps, and short, elastic feet, but people of the same race who pass their childhood in cold climates often have long feet with low arches?

Instinct as a Guide for using the Muscles. — The instinctive feeling called *fatigue tells us when to rest*. There is also a *restless, uneasy feeling that comes over a natural, human being when confinement and restraint of the muscles have reached an unhealthy limit*. This feeling should not be repressed for long at a time. Many, ruled by avarice, ambition, interest in sedentary work, or by a false conception of duty, have repressed this feeling and have lost it. When repeatedly repressed, it is lost, and the person has a feeling of languor, and is disinclined to the very activity that his health demands.

Exercise and Climate. — The colder the climate, the more exercise is required to keep the body in perfect condition, and the pleasanter it is to take exercise. English ladies think nothing of taking a ten-mile walk for recreation ; but this would be too much in many parts of the United States. In our warmest states and in the tropics, one hour's vigorous physical labor a day, combined with the ordinary activities of life, will keep a person in good condition ; but this amount is absolutely necessary, for if all vigorous exercise is omitted, the heat causes the body

to become so relaxed, and the organs so sluggish, that sound health will probably be lost. In the colder states, exercise for several hours is needed daily.

Mental and Physical Labor.—The senseless idea that physical labor is degrading, has led to the ruin of the health of thousands. No truly refined person can entertain such an idea. To do physical labor in a stupid way is a disgrace. An example of this is a farmer that works with dull tools, and leaves his implements in the rain to rust, or a builder that does not build well. *A laborer that never reads a book or cultivates his mind is as worthy of respect as a writer or professional man who uses his mind only and neglects his body, allowing his muscles to dwindle, his lungs to become flattened, his digestive canal foul, and his tissues impure.*

Complete Living.—Numberless people have devoted themselves to an intellectual occupation, and planned to keep their bodies sound by gymnastics and special exercises. Because of the monotony of exercises, they are soon given up in nearly every instance. *The safest way is never to allow all the energies to be devoted to a one-sided occupation, but so to plan one's life and work that a part of the time is devoted to some physical work*, whether it be in a garden, workshop, or orchard; in walking a long distance to the office; at bookbinding, cooking, wood carving, or any one of various other useful occupations. The result of manual training shows *that not only strength of body, but strength of mind, is promoted by physical labor.* It may be a part of the secret of the greatness of many noted men that they recognized this relation, and helped the mind to do its best by taking care of the body. Gladstone's favorite exercise was wood chopping, and he possessed great mental strength at eighty years of age; Peter the

Great worked as a ship carpenter while emperor ; Franklin, the great scientist and statesman, was a printer, but he neglected exercise and became gouty when old ; George Washington was a surveyor and farmer.

Alcohol and Muscular Strength. — Benjamin Franklin, one of the wisest and greatest of Americans, was a printer when he was a young man. In his autobiography he gives an account of his experience as a printer in London. He says : " I drank only water ; the other workmen, fifteen in number, were great drinkers of beer. On occasion I carried up and down stairs a large form of types in each hand, when others carried but one in both hands. They wondered to see, from this and several instances, that the Water-American, as they called me, was stronger than themselves, who drank strong beer. My companion at the press drank every day a pint before breakfast, a pint at breakfast with his bread and cheese, a pint between breakfast and dinner, a pint at dinner, a pint in the afternoon about six o'clock, and another when he had done his day's work. I thought it a detestable custom, but it was necessary, he supposed, to drink strong beer that he might be strong to labor."

EXERCISES IN WRITING. — The Right and the Wrong Way to Ride a Bicycle. Write a Letter to a Friend who has begun to Drink. Pay Day at a Factory. A Graceful Form : how Acquired ; how Lost.

PRACTICAL QUESTIONS. — 1. Can we always control the voluntary muscles? Do we shiver with the voluntary or involuntary muscles? 2. If a man had absolute control over his muscles of respiration, what might he do that he cannot now do? 3. Why is one who uses alcoholic drinks not likely to be a good marksman? 4. Why should a youth who wishes to excel in athletic contests abstain from the use of tobacco? 5. Is there any relation between the amount of bodily exertion necessary for a person's health and the amount of wealth he possesses? 6. Can you relax the chewing muscles so that the lower

jaw will swing loosely when the head is shaken? Can you relax your arm so that it falls like a rope if another person raises it and lets it fall? **7.** The average man has sixty pounds of muscle and two pounds of brain: one half of the blood goes through the muscles and less than one fifth goes through the brain. What inference may you draw as to the kind of life we should lead? **8.** Why is a slow walk of little value as exercise? **9.** How can we best prove that we have admiration and respect for our wonderful bodies? **10.** Which of your legs do you exert more in walking? (The foot on that side is larger, as shown by the fit of the shoe.) If you were lost on a prairie, to which side would you turn while trying to go straight? **11.** Show that physical labor is a great blessing. Show that false pride causes more ill health than almost anything else. Does paleness indicate refinement or impure blood? **12.** If fat accumulates at the waist and a man tries to restrain it with a leather belt, or a woman uses a corset, why do the abdominal walls relax? Why does the fat increase still faster? What would be a successful way of diminishing the fat? How may a horse be prevented from becoming fat? **13.** Why is the ability to relax the muscles thoroughly of great benefit to the health? How is this ability tested? (Question 6.)

KEY TO MUSCLE CHART: **Plate III, The Head.** Described on Plate. **Plate IV, The Trunk.** The bowing muscle (*sternomastoid*) goes from behind ear to breastbone; see 5, Fig. 63. The trapezius muscle draws head and shoulders back (attached along the spine). The shoulder-cap muscle (*deltoid*) lifts whole arm up and out. Its antagonist (*pectoralis*) draws arm down and in. The climbing muscle (*latissimus*) draws arm down and back. The pushing muscle (*serratus*) draws shoulder blade forward. The straight muscle (*rectus*) and the external and internal oblique muscles draw the abdominal walls in and expel the breath. The standing muscle (*gluteus*) makes body erect after stooping. **Plate V, The Arm.** Fig. 66. Biceps, 1, bends elbow; 3, 4, bends fingers; 2, 5, bends wrist. Fig. 67, Triceps, straightens elbow; extensors straighten thumb, fingers, and wrist; ligament binds tendons down. **Plate VI, The Leg** (front view). Fig. 68. 1, 4, swings leg outward; 6, swings leg inward; 7, straightens knee; 8, 5, tailor's muscle crosses knee; 2, 3, 9, nerves and blood vessels. Fig. 69, Tibialis, raises instep. Extensors straighten toes. Soleus, see Fig. 71. Ligament binds down tendons. **Plate VII.** Described on Plate.



FIG. 58.—Improper position; causes spine to curve to side; raises one hip and shoulder above the other.



FIG. 59.—Best habitual position; chest is free to expand, and weight is easily shifted from one foot to other.



FIG. 60.—Desk too low. (Jegi.)



FIG. 61.—Correct position.



FIG. 62.—Slipping down in seat.

In five plates (after Cunningham)

PLATE III.—THE HEAD.

PLATE VI.—THE LEG (front view).

PLATE IV.—THE TRUNK.

PLATE VII.—THE LEG (rear view).

PLATE V.—THE ARM.

For key to chart, see page 70. The positions and functions of the muscles are to be learned; but do not learn their names, which are given only for reference.

PLATE III

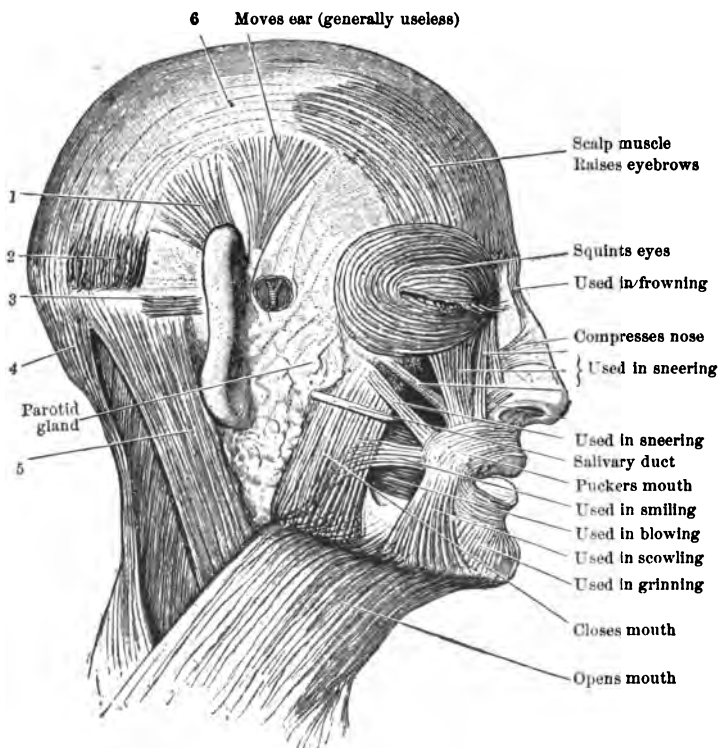


FIG. 63. — MUSCLES OF HEAD.

1. Lifts ear (used by few). 2 Scalp muscle (used by few). 3. Draws back ear (used by few). 4. Throws head back. 5. Turns head to left, or, acting with its partner, bows the head. 6. Tendon connecting the two scalp muscles.



FIG. 64. — MUSCLES OF TRUNK (rear view).

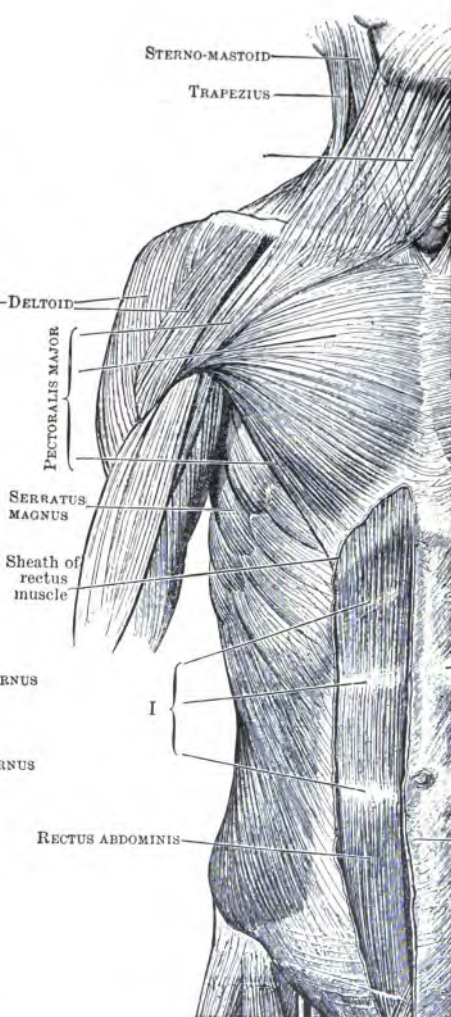


FIG. 65. — MUSCLES OF TRUNK (front view).

FIG. 66. — ARM (front view).

1, 2, 3, 4, 5. Muscles.
 1', 2', 3', 4', 5', Tendons.



FIG. 66.

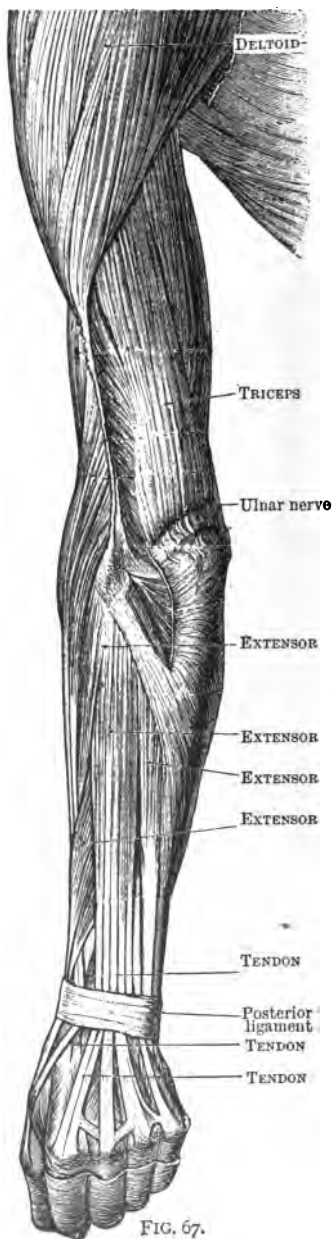


FIG. 67.

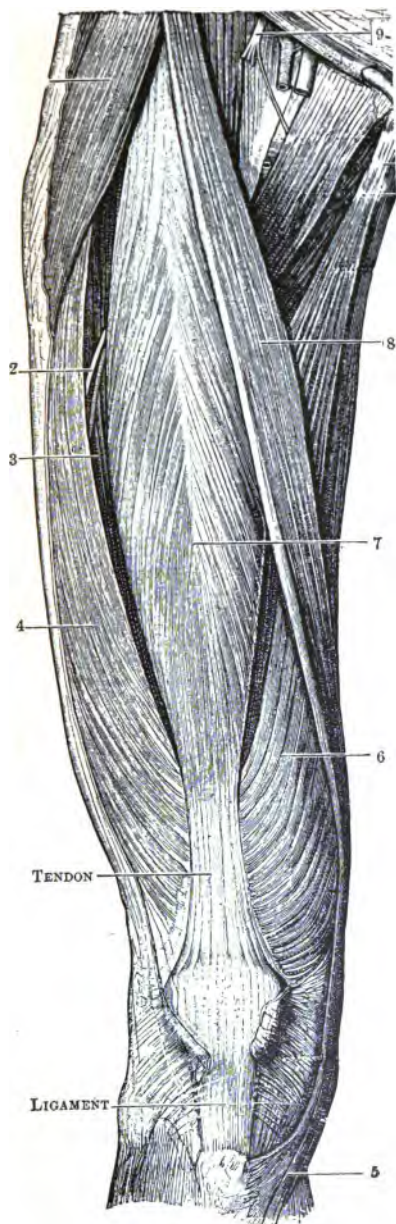


FIG. 68.

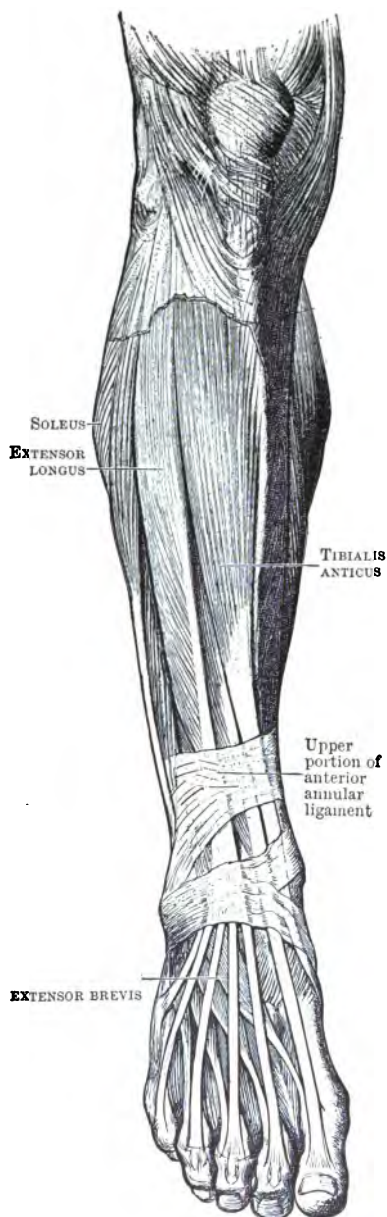


FIG. 69.

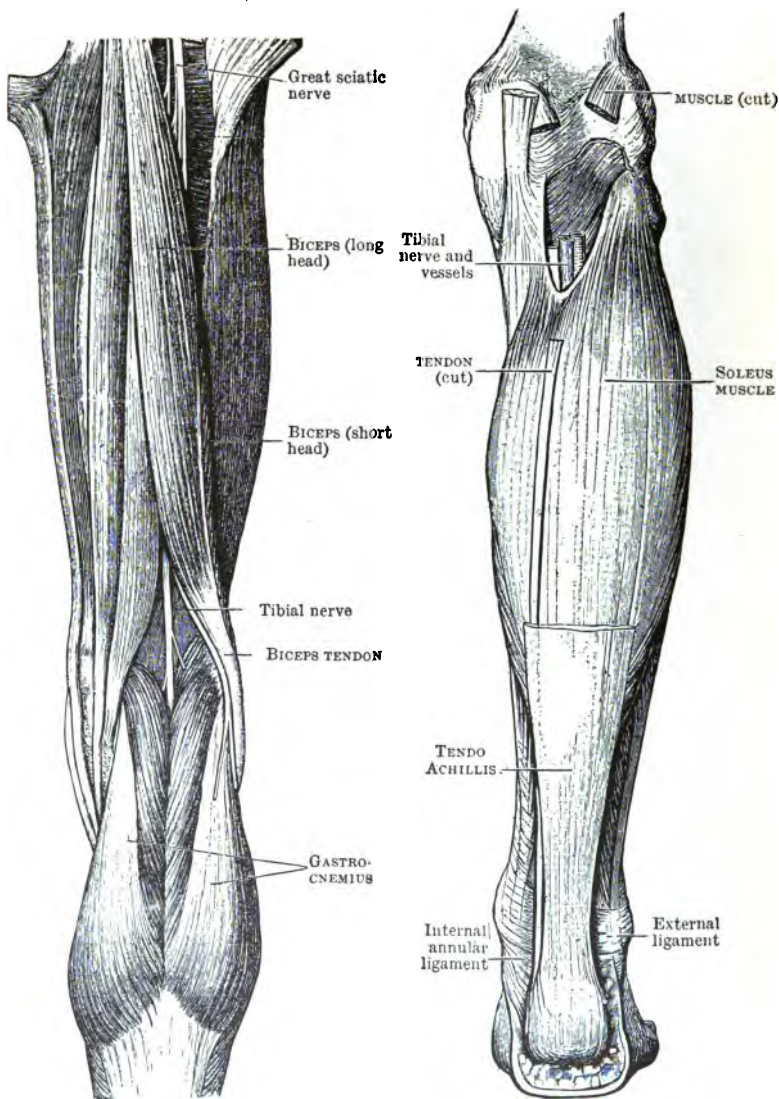


FIG. 70. — MUSCLES AT BACK OF THIGH.

FIG. 71. — MUSCLES OF CALF.

Figs. 70, 71. Biceps bends knee. Gastrocnemius (removed in Fig. 71) draws up heel and raises body upon toes; soleus lies beneath it and has the same function. Both muscles are attached to the tendon of Achilles, the largest tendon in the body.

PHOTOMICROGRAPHS (PEABODY)

(Photographs taken through a microscope)

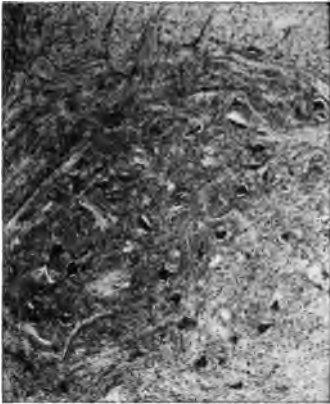


FIG. 72. — SECTION OF SPINAL CORD, showing nerve cells (large black spots) with their branches (black dots and lines). Five bundles of nerve fibers are shown near upper margin.



FIG. 73. — MUSCULAR AND OTHER LAYERS IN WALL OF STOMACH.

1. Mucous lining. 2. Layer of blood vessels and connective tissue. 3. Muscular layer (involuntary muscle). 4. Connective tissue fibers.

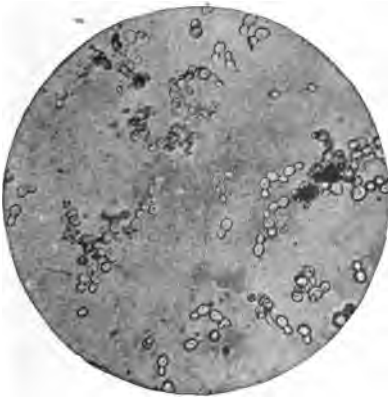


FIG. 74. — YEAST CELLS (magnified 200 diameters, or 40,000 areas). Yeast cell's change sugar into alcohol and carbon-dioxid gas.

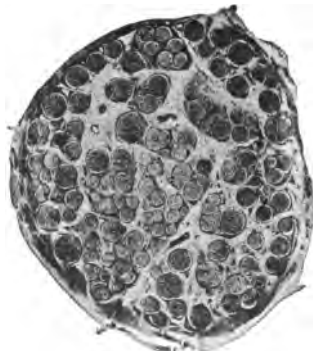


FIG. 75. — LARGE NERVE TRUNK, such as supplies the muscles. Cross sections (magnified 6 diameters), showing bundles of nerve fibers.

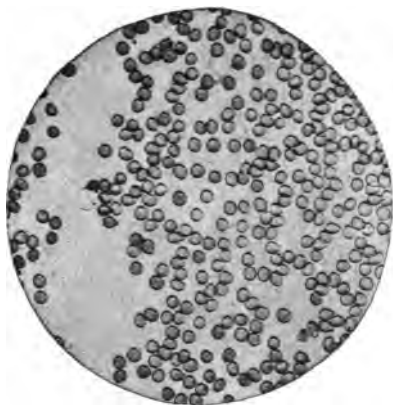
PHOTOMICROGRAPHS (*Continued*)

FIG. 76. — HUMAN BLOOD CELLS (magnified 40,000 areas), showing many red cells and a single white blood cell on left (larger than red cells).

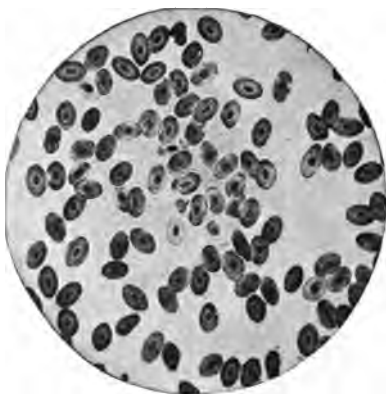


FIG. 77. — FROG'S BLOOD (magnified 2500 areas). Red cells oval, nucleated, and larger than human blood cells. Nuclei of two white cells visible near center.

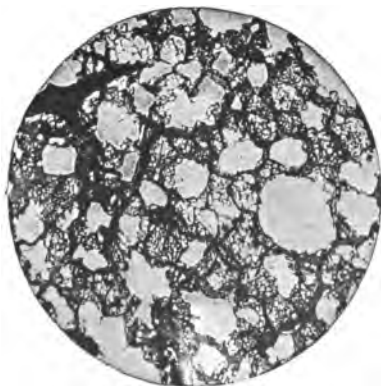


FIG. 78. — CAPILLARIES around air sacs of lungs (30 diameters). Air sacs in white spaces. Dark lines are capillaries.



FIG. 79. — CAPILLARIES among fibers of voluntary (cross striped) muscle. Compare with colored Figure 12.

CHAPTER V

THE CIRCULATION

The Cells have a Liquid Home. — The ameba, one of the simplest of all animals, lives under water. The cells in the body of man, the highest of all animals, also live in a watery liquid. This liquid is called *lymph*. The cells cannot move about as the ameba does to obtain food, so the *blood* brings the food near them and it soaks through the blood tubes into the lymph. As the water in a sponge surrounds every fiber of the sponge, so the lymph bathes every cell and holds the food ready for use (see colored Fig. 6). The ameba gives off waste material into the water; the cells of the body give it off into the lymph to be carried off by the circulation. The blood, then, has *two functions*: (1) to take nourishment to the tissues; (2) to take away waste material from them.

The Organs of Circulation. — These are the *heart* (Fig. 80), which propels the blood; the *arteries*, which take blood away from the heart (Plate X); the *veins*, which take the blood back to the heart; and the *capillaries* (Fig. 81), which take the blood from the arteries to the veins.

The heart (Fig. 80) is a cone-shaped organ about the size of its owner's fist. It lies in a diagonal position, behind the breastbone, with the small end of the cone extending toward the left. The smaller end taps the chest wall at a point between the fifth and sixth ribs on the left

side. The beat of the heart is felt most plainly at this point, and this has given rise to an erroneous belief that the heart lies on the left side of the body. It is almost exactly in the center and lies largely behind the breastbone.

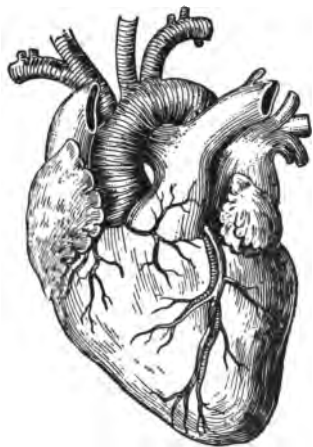


FIG. 80. — THE HEART.

Experiment 12. Get a sheep's or beef's heart from the butcher. Get the whole heart, not simply the ventricles (as usually sold). Note the blood vessels, four chambers, thickness of different walls, valves, cords, openings.

Why the Heart is Double. —

There must be a pump to receive the impure blood from the body and send it to the lungs to get oxygen from the air, and there must be another pump to send the pure blood from the lungs back to the body. Hence there are two pumps bound together into one heart, beating at the same time like two men keeping step, or, like two carpenters keeping time with their hammers. There are valves in the heart, as in other pumps. These valves are so arranged that when any part of the heart contracts and forces the blood onward, the blood cannot return after that part of the heart relaxes. How are the pumps placed with reference to each other? Is one behind the other? Or is one above the other? No, they are side by side, with a fleshy partition between them (Fig. 82). The one on the right moves the impure blood from the



FIG. 81. — CAPILLARIES connecting artery (a) with vein (b).

body to the lungs, and the one on the left moves the pure blood from the lungs to the body. There is no direct connection between the right and left sides of the heart. Each pump is constructed alike and has the same parts.

Each pump has the following parts. (Fig. 82, colored Fig. 10): (1) *large veins* bringing the blood; (2) a weak, thin-walled receiving chamber called an *auricle* (see Fig. 82); (3) a large *valve* situated in the central part of the heart, leading down into (4) a strong, thick-walled sending chamber called a *ventricle*; (5) a large *artery* leading from the heart, and provided with a valve, so that the blood cannot flow back. The left ventricle has thicker walls than the right ventricle (see Fig. 82), because it must send the blood all over the body, while the right ventricle sends the blood to the lungs which surround the heart.

To trace one complete circuit of the blood (see colored Fig. 1), let us begin with the blood in the *capillaries* of the outer tissues, such as the skin or muscles. The blood goes through small veins which unite into *two large veins* through which it enters the *right auricle*, goes through the *tricuspid valve* into the *right ventricle*, then through a *semilunar valve* into the *pulmonary artery* leading to the *lungs*. Becoming purified while passing through the *capillaries of the lungs*, the blood goes through the

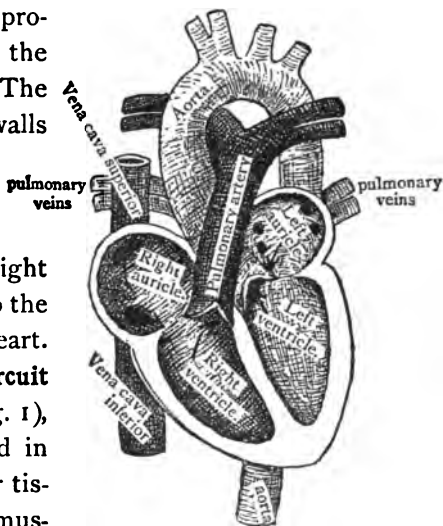


FIG. 82.—DIAGRAM OF HEART.

Notice the two dark spots in the right auricles, and four dark spots in left ventricles where the veins enter. Does the aorta pass in front of, or behind, the pulmonary artery?

pulmonary veins to the *left auricle*, then through the *bicuspid*, or mitral valve, to the *left ventricle*, whence it is forced through a *semilunar valve* into the largest artery of the body, called the *great aorta*. Thence it goes to the *smaller arteries*, and then to the *capillaries* of the tissues in general, thus completing the circuit.

Seen under the microscope the arteries and veins show that they are made of *three kinds of tissues* arranged in *three coats* (Fig. 83): a tissue resembling epithelial tissue (see p. 12), as a lining to prevent friction; connective tissue (see p. 11), to give elasticity; and muscular tissue (see p. 9), to enable the vessels to change in size. Let us inquire why blood vessels must have these three properties.

Why the Blood Vessels must be Elastic. — The aorta and its branches are always full of blood. When the left ventricle with its strong, muscular walls contracts (Fig. 82), the blood in the aorta and small blood tubes *cannot move forward fast enough to make room for the new supply so suddenly sent out of the ventricle*. Where can this blood go? If a cup is full, it cannot become more full; not so with an artery. The elastic connective tissue allows it to expand as a rubber hose does under pressure. The first part of the aorta having expanded to receive the incoming blood, the stretched elastic walls contract and force blood into the portion of the aorta just ahead, forcing it to expand in turn. Thus *a wave of expansion* travels along the arteries. This wave is called the *pulse*.

The pulse may be most easily felt in the wrists and neck. As the artery stretches and springs back, one beat of the pulse is felt. In men there are about *seventy heart beats or pulse-beats a minute*. In women the rate is about eighty a minute. It is slowest when one is lying down, faster while sitting, still faster when standing, and fastest of all

during running or other violent exercise. You should not think that the muscular or middle layer of the artery actively contracts and helps to send along the pulse wave; for this wave is simply the passive stretching and contracting of the elastic tissue, and travels like a wave passing a pond when a stone is dropped into the water. The force of the pulse is furnished, not by the muscle fibers in the artery, but by the heart; the outer, or connective tissue, coat enables the pulse to travel. You have yet to learn the purpose of the muscular layer in the arterial wall.

Why and how the Blood Vessels vary in Size from Time to Time. —

The body of an adult contains about five quarts of blood. You have learned that the blood furnishes the nourishment needed for the activity of each organ. The more vigorous the work of any organ, the greater is the amount of blood needed. *The whole amount of blood in the body cannot be suddenly increased, but the muscular coat of the arteries going to the working organ relaxes, and the arteries are enlarged by the pressure from the heart.* Con-

sequently, more blood goes to the active organ, and the other organs get along with less blood for the time. When we are studying, our brains get more blood; when running, the leg muscles get more; after a hearty dinner, the stomach and intestines get more than any other part of the body. Why is it difficult to do the best studying and

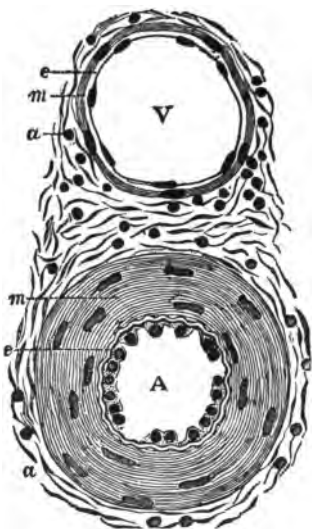


FIG. 83.—SECTION OF ARTERY, A, AND VEIN, V, showing inner coat, *e* (endothelial); middle coat, *m* (muscular); and third coat, *a* (connective tissue).

digest a meal at the same time? We see that the muscular coat of the arteries is a very useful coat, for it enables the supply of blood to be increased in any organ which is in special need of it. Without these muscles, all parts would receive blood equally at all times, whether they needed it or not. *With these muscles the particular amount of blood that flows to each organ may be modified.* When all the organs need a greater supply of fresh blood at the same time the demand can be met only by the heart beating faster and stronger. When all the organs need less blood the heart beats more slowly, as during sleep.

Why the Blood Vessels must be Smooth.—The inner coat of the heart and other blood vessels is made of tissue like the epithelial tissue which forms the epidermis and the

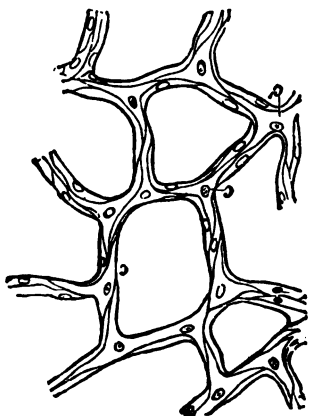


FIG. 84.—CELLS forming the walls of capillaries. Notice that each cell has a nucleus and three branches.

smooth lining of the mouth and other organs. The purpose of this tissue is to lessen friction, and thus save the work of the heart. The friction is greatest in the capillaries because of their small size. The inner coat of smooth cells is the only coat that is prolonged to form the capillaries (see Fig. 84).

The capillaries are small, thin, short, and very numerous. *They are very small* so that they may go in between the cells of the tissues (colored Figs. 6 and 12). *The capillaries are very thin* so that the nourishment from the blood may pass readily into the tissues, and the waste material pass readily into the blood. *They are very short* so that the friction may be less; and *they are very numerous* so that all parts of the tissues may

be supplied with blood, and that the blood may flow very slowly through them. Because of the number of the capillaries, their total volume is several hundred times larger than the volume of the arteries that empty into them, or of the veins that flow from them. Hence the blood flows slowly through the capillaries, as water flows slowly through a lake along the course of a river. All the changes between the blood and the lungs, and between the blood and the tissues, take place in the capillaries, and the object of the other parts of the circulation is merely to move the blood continually through the capillaries (see colored Figs. 7 and 8).

The veins have very thin, soft walls in comparison to the arteries. There is no pulse in the veins, and the pressure due to the heart beat is very slight in the veins. There are other aids to the flow of blood in the veins which we shall soon study.

The effect of gravity is to retard the flow in certain parts of the body and aid the flow in other parts, according to the position of the body.

Experiment 13. Hold the right hand above the head for a few minutes. At the same time let the left hand hang straight down. Then bring the hands together and see which is of a darker red because of containing more blood. Now reverse the position of the hands for a few minutes, and find whether the effect is reversed. The downward flow of blood is aided by the weight of the blood, and the upward pressure is retarded by it. Garters compress the soft, thin walls of the veins more than the thick walls of the arteries, and serve to retain the blood below the knee. As the return flow is also hindered by the weight of the blood, varicose veins, which are veins permanently enlarged, occur below the knee oftener than in any other part of the body.

Fainting is usually due to *lack of blood in the brain*, which in turn results from a weakening of the heart beat. Since the brain cannot work without fresh blood, fainting is accompanied by unconsciousness. Recovery from fainting is aided by loosening the clothing at the neck and by placing the head of the patient a little lower than the body so that the weight of the blood may aid the flow to the brain. Dashing a little cold water in the face shocks the nerves and arouses the heart to stronger beats.

Observations on the Blood Flow in the Veins. — Place the tip of the middle finger on one of the large veins of the wrist; with the forefinger then stroke the vein toward the elbow so as to push the blood from a portion of it, keeping the fingers in place. The vein remains empty between the fingers. *Lift the finger nearer the heart and no blood enters the vein; there is a valve above which holds it back. Lift the other finger and the vein fills instantly.* Stroke a vein toward the hand, and notice that the blood causes the veins to swell up into little knots where the valves are. (Experiments upon veins are plainest with adults whose veins are large.) The veins have valves placed frequently along their course (Fig. 85). These valves are pockets made by a fold in the inner coat of the wall of the vein. When a boy places his hand in his pocket, the pocket swells out; but if he rubs his hand on the outside of the pocket from the bottom toward the top, it flattens down. So with the action of the blood upon the valves in the veins.

How Muscular Exercise aids the Heart. — *When a muscle contracts* it hardens and presses upon a vein which goes through the muscle, and *the blood is pressed out of the vein* (see Fig. 85). The blood cannot go toward the capillaries, for the valves fill and close when it starts that way; so it

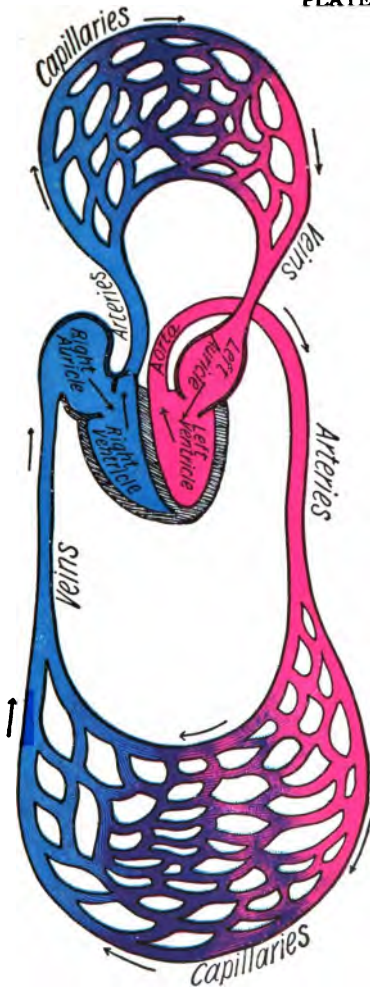


FIG. 1. — DIAGRAM OF CIRCULATION.

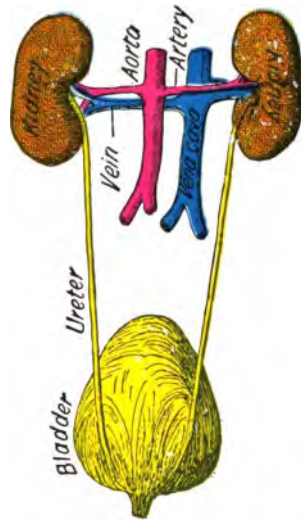


FIG. 2. — KIDNEYS AND BLADDER.



FIG. 3. — CELLS AND CAPILLARIES OF LIVER (magnified).

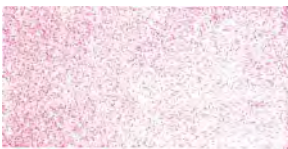


FIG. 4. — HEALTHY MUCOUS MEMBRANE.



FIG. 5. — MUCOUS MEMBRANE inflamed by catarrh or alcohol.



PLATE XI

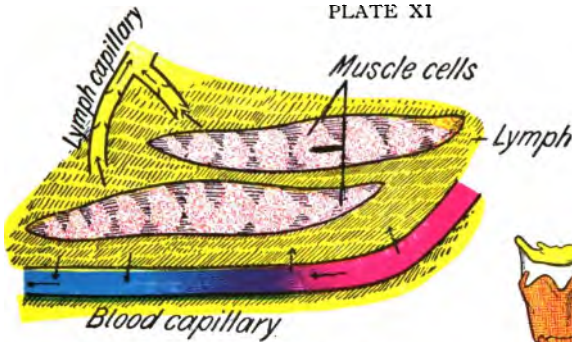


FIG. 6. — THE LYMPH SPACES.

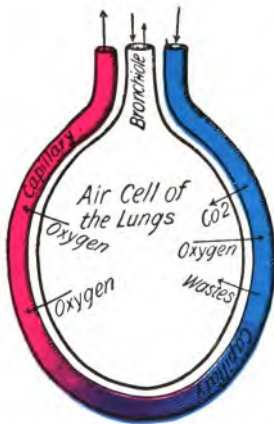


FIG. 7. — DIAGRAM OF AIR CELL.

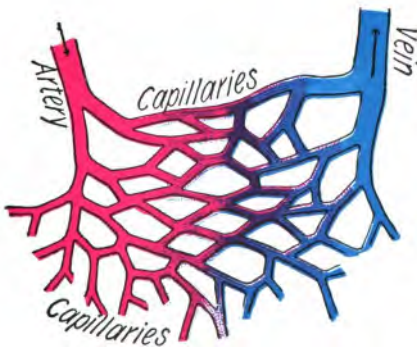


FIG. 8. — DIAGRAM OF CAPILLARIES.

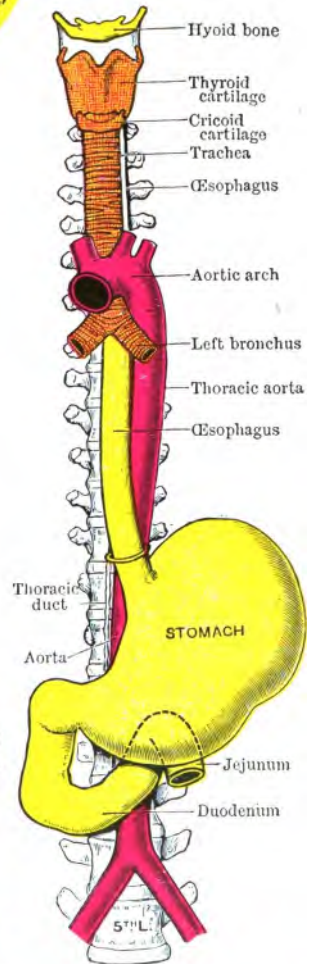


FIG. 9. — RELATION OF SPINE, TRACHEA, AORTA, GULLET, AND STOMACH.

PLATE XII

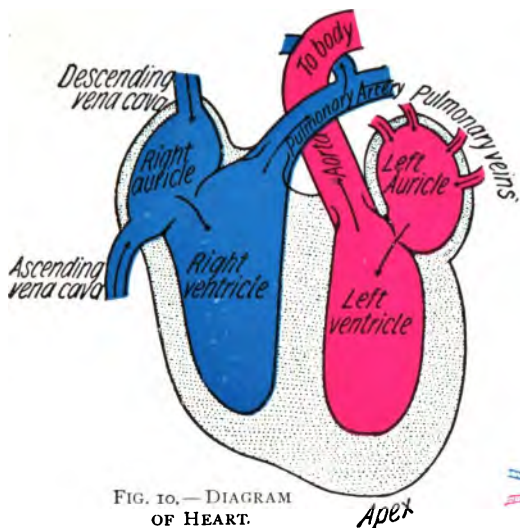


FIG. 10. — DIAGRAM OF HEART.

FIG. 11. — GASTRIC GLAND, WITH CAPILLARIES.

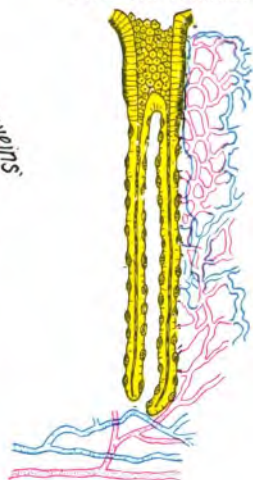


FIG. 12. — THREE MUSCLE FIBERS.

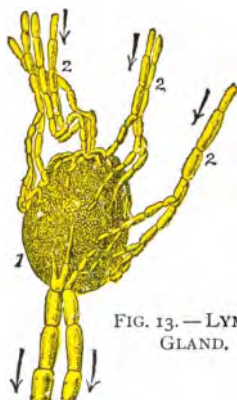
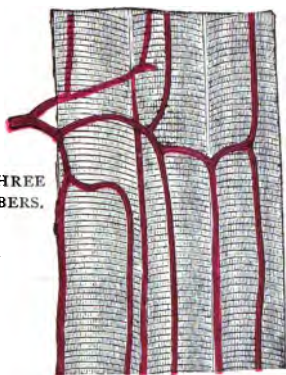


FIG. 13. — LYMPH GLAND.

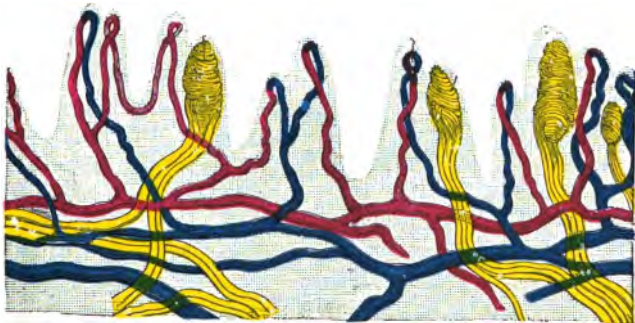


FIG. 14. — SIX PAPILLÆ, with capillaries and touch bodies.



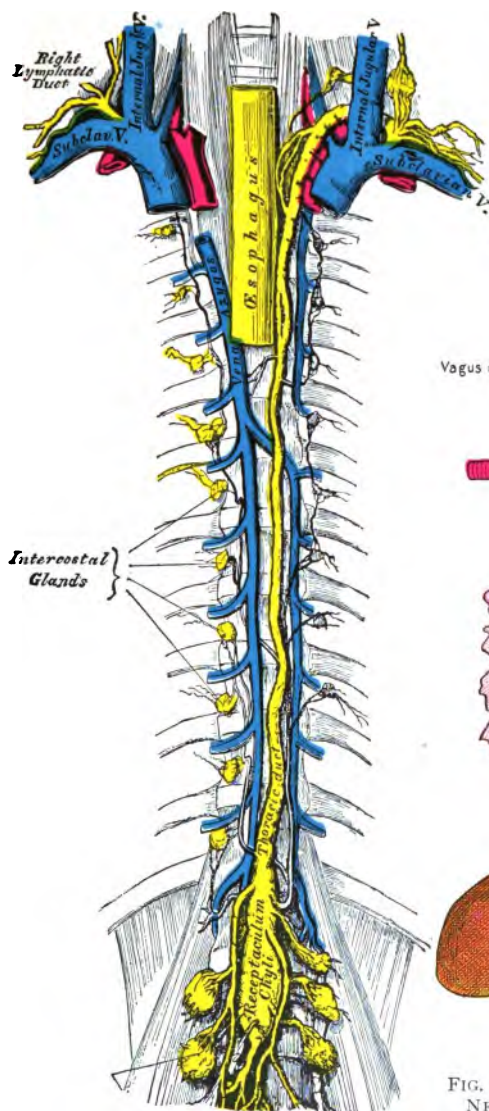


FIG. 15. — THE THORACIC DUCT

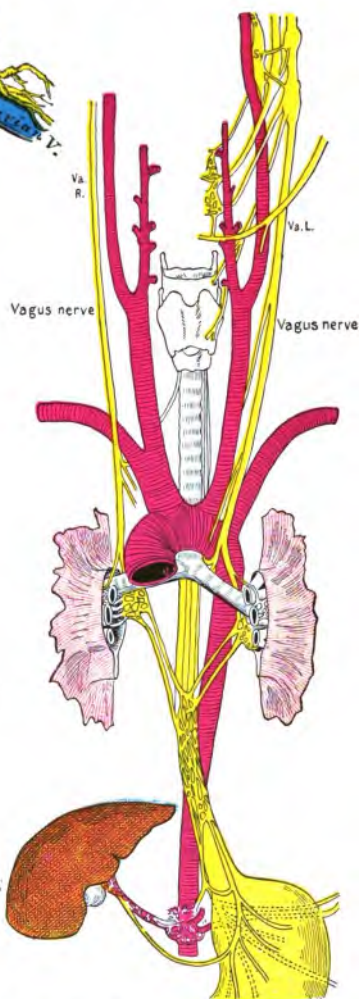


FIG. 16. — RIGHT AND LEFT VAGUS NERVES to lungs, aorta, heart (removed), stomach, and liver. (Diagram.)



all must go out toward the heart. *When the muscle relaxes*, the blood that has been pressed forward cannot go back because of the valves, but the valves nearer the capillaries open, and *the veins are filled from the capillaries.* (Fig. 81). When the muscle contracts again, the same effect on the blood movement is repeated. We see, therefore, that every contracting muscle converts into a pump the vein running

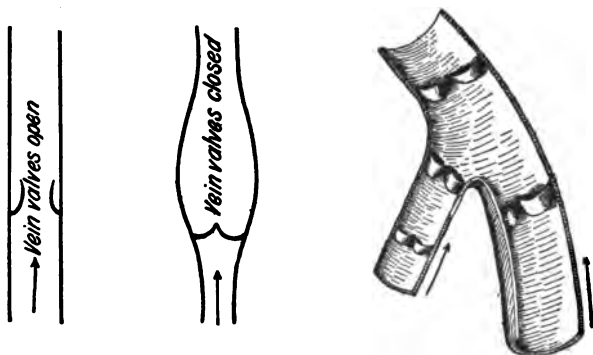


FIG. 85.—Showing valves in veins. (Jegi.)

through it, and when a person works or exercises, many little pumps are working all over the body, aiding the heart in its function. This aid makes the blood flow faster and relieves the heart of part of its work, so that it beats faster, just as a horse might trot faster if another horse helped to draw the load. Why does the pressure of a contracting muscle upon an artery not aid the blood flow in the artery?

How Breathing aids the Heart.—Breathing is a blood-pumping process as well as an air-renewing process. When the chest expands, blood is drawn into it. When the chest contracts, the flow of blood away from it is aided. As the chest expands, the downward pressure of that great, broad muscle, the diaphragm (Fig. 96), compresses the liver,

stomach, and other abdominal organs, and forces the venous blood upward into the expanding chest, thus helping it on its way to the heart. But if the abdominal wall is weakened by tight lacing or by the pressure of belts and bands which support the clothing, the weak abdominal wall yields to the downward pressure of the diaphragm, and no compression of the liver or aid to the circulation will result.

How to strengthen the Heart. — The heart is a muscle, and the muscles of an idle man, or an exclusive brain

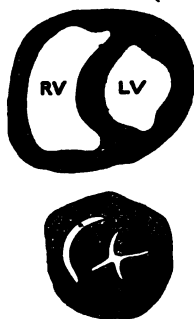


FIG. 86. — The ventricles of a dog's heart relaxed (above), and contracted (below).

worker, lose strength. The heart may be made strong by exercise, as may any other muscle. *The same exercise which strengthens the arms and legs strengthens the heart also by compelling it to work more in order that the other muscles may have enough fresh blood.* One who has neglected physical exercise should take it up gradually, and avoid causing the heart to palpitate with unpleasant strength. When the heart has been excited by exercise, the pulse should return to its normal rate after a few

minutes of rest if the exercise has not been excessive.

How the Blood Vessels are Controlled. — Evidently the blood vessels are not regulated by the will. We cannot voluntarily increase the beating of the heart, or cause it to slacken its action. Even an actor cannot cause his face to turn pale or to blush at will. This is because the tiny muscles in the walls of the blood vessels are involuntary muscles. They are controlled by nerves (the sympathetic nerves) which are not subject to the will (see Fig. 156). The nerve center which controls the blood vessels is

located in the top of the spinal cord at the base of the brain. When cold air strikes the skin, the nerves near the arteries are stimulated, the arteries in the skin contract, and the skin turns white. When the heat from a hot fire strikes the skin, the nerves are soothed, the arteries relax, and the face becomes red. When the stomach is burdened with food, the heart beats faster and sends more blood to aid in digestion. When we run fast, the heart beats fast to supply more blood to the muscles, but it slows down as sleep comes on, that the body and brain may rest.

There are Two Kinds of Nerves that affect the Heart. — One kind, called the sympathetic nerves, brings impulses which increase its action. Another kind, the two vagus nerves, serves to decrease the action of the heart (see colored Fig. 16). This pair of nerves comes directly from the brain; the sympathetic nerves do not (see *sy*, colored Fig. 16).

How the Heart is Nourished. — The heart has a smooth, sleek lining which will not absorb food from the blood. Therefore, the heart does not get food from the blood that fills its chambers; but the first artery which branches from the aorta goes down into the walls of the heart to carry nourishment to it.

THOUGHT QUESTIONS. — The Complexion. 1. Check words which describe a healthy skin: hard, soft, dry, moist, flexible, elastic, stiff, firm, flabby, smooth, dingy, rough, pink, yellow, pale, velvety. 2. What is the best means of improving the color of the skin? The worst means? 3. Is a "white lie" less deceptive than a pink one? 4. What undesirable qualities (Question 1) do dry powders, hot winds, and overheated rooms give to the skin? Why is their effect the same? 5. Think of five girls under twelve years of age, and five grown young ladies. How many of each have smooth, rosy complexions? Dingy, bad complexions? 6. Pimples are caused by germs. Why does thorough and frequent washing of the face tend to prevent them? 7. Why does

thorough washing each day, followed by prolonged and vigorous rubbing with a towel, make the skin smooth, pink, and velvety? **8.** Why does neglect to rub the face after washing it, and the use of face powders, cause blackheads, and make the skin flabby, dark, and rough? **9.** Is a powdered face or a clean face more agreeable to a refined person? **10.** Why does eating too much and working too little cause a bad complexion? **11.** Show how ignorant treatment of the complexion causes many ladies to appear older or less healthy than they really are?

Experiment 14. Fine dry powder is one of the most powerful means of extracting moisture. Moisten two pieces of leather. Apply face powder to one and place the other in the sun. Which piece dries first?

The Blood which flows from a cut finger seems to be a bright red throughout. When a drop of it is looked at through a microscope, however, the liquid itself is seen to be almost as clear as water. This liquid is called the *plasma*. By means of the microscope the red color of the blood is seen to be produced by millions of round red disks, floating about in it. The disks are called *red corpuscles* (Fig. 76). By patient search, a few irregularly shaped bodies, almost transparent, and called *white corpuscles*, may be found. The red corpuscles go only where the plasma carries them. The white corpuscles sometimes leave the blood vessels entirely. At times one may be seen shaped like a dumb-bell, half of it through the wall of the blood vessel, and half still in the blood vessel. After the corpuscle is out, no hole can be found to account for its mysterious passage.

Experiments. — 15. Examine a drop of blood under the microscope, first diluting it with a little saliva. **16.** Wrap a small frog in a moist cloth, lay on a piece of glass, place under the microscope, and study the circulation in the web of its foot.

The Use of Each Part of the Blood. — The *plasma* keeps the blood in a liquid state, so that it may flow readily; the plasma also transports the food that has been eaten and digested, and carries away waste material to the kidneys.

The *red corpuscles* transport the oxygen from the lungs to the tissues. The *white corpuscles* devour and destroy irritating particles such as drugs, poisons, and germs. They are of great importance in purifying the blood and as a protection against disease (Fig. 87).

The Pulmonary and the Systemic Circulations. — *Each of these is really only a part of the general circulation.* The blood vessels which lead the blood from the heart to, through, and from the lungs constitute the so-called pulmonary circulation. The vessels which lead the blood from the heart to, through, and from the other organs constitute the systemic circulation.

The vessels which lead the blood from the heart to, through, and from the other organs constitute the systemic circulation.

Incorrectness of the Terms "Arterial" and "Venous Blood." By venous blood is usually meant impure blood, but the blood in the pulmonary veins is not impure, having just been purified in the lungs. By arterial blood is usually meant pure blood; but blood in the pulmonary artery is on its way to the lungs to be purified. *Hence arterial blood is not always carried in arteries, nor venous blood in the veins.* The terms are appropriate only when applied to the systemic portion of the circulation. Oxygenated blood and deoxygenated blood would be correct expressions.

The Three Purifications of the Blood.

Portal Circulation. When the blood is forced out by the heart, the part that goes to the stomach and intestines where the food is absorbed is gathered up by a large vein, called the *portal vein*, and carried to the liver. In the

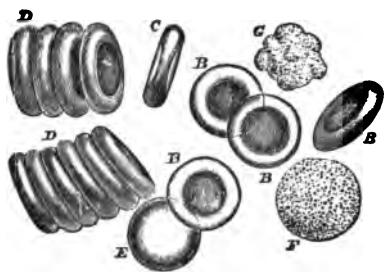


FIG. 87.—BLOOD CORPUSCLES.

B, red cells seen from the side; *D*, red cells seen on edge; *G*, *F*, white blood cells.

liver the blood is purified by impurities being burned up and changed into bile. The blood is then carried from the liver to the heart by a large vein. See colored Figure 3, showing the circulation of the blood among the liver cells.

Renal Circulation. Two other branches from the aorta carry blood to the kidneys. There the urea and a large amount of water are taken out, and the purified blood is emptied into the large vein that leads up to the heart. See colored Figure 2, Plate X.

Pulmonary Circulation. This is the circulation through the lungs and has already been described. This circulation removes carbon dioxid gas from the blood. Some impurities escape from the blood through the skin. See diagram of an air cell in lungs, colored Figure 7.

Coagulation. — So long as blood is in an uninjured blood vessel it remains a liquid. In a few minutes after it escapes from a vessel, it forms into a stiff, *jellylike mass called a clot*. The process of forming the clot is called coagulation, and it is brought about by albumin which is always in the plasma of healthy blood. *The albumin forms into a network of fine threads throughout the mass*, and the corpuscles become entangled in the meshes. The clot consists of the albumin and corpuscles; the watery portion of the blood, called the *serum*, separates from the clot (Fig. 88). The property of coagulating is of great value in saving life, as the clot often plugs up a cut blood vessel.



FIG. 88. — BLOOD CLOT separated from serum.

Veins and Arteries Compared. — The veins have *soft walls* and the arteries have *elastic walls*. When a vein is cut, it may usually be closed by pinching the walls of the end together. If an artery is cut, the *walls will not readily*

stick together, but often stand open until the end of the artery is tied. For this reason, and because an artery is subject to the direct pressure of the heart, a cut artery is more dangerous to life than a cut vein. Because of the toughness of the arteries, and because they are *located close to the bones*, they are less likely to be cut than the veins, which are softer and nearer the surface. A cut artery may be known from a cut vein by the brighter *color of the blood*, and by the flow being *stronger at each heart beat*, while the flow from a vein is uniform. Pressure to stop the flow of blood from an artery should be applied *between the cut and the heart*; but when the blood comes from a vein the pressure should be applied *to the side of the cut farthest from the heart*. The veins *empty into the auricles*; the arteries lead *from the ventricles*; and there is a semilunar valve at the origin of each artery.

THE LYMPHATIC SYSTEM

This system contains the lymph. It consists of lymph spaces, lymph tubes, and lymphatic glands. *Lymph corresponds nearly to the blood without the red corpuscles*. You have often seen it in a blister, or oozing out where the skin has been grazed without breaking a blood vessel.

Necessity for Lymph Spaces.—The body cannot be nourished with the albumin, sugar, oxygen, and other things carried by the blood, until this food passes out of the blood vessels. The food leaves the blood through the thin walls of the capillaries. Many of the cells do not touch the capillaries, and the *lymph penetrates the spaces between the cells to reach them* (see colored Fig. 6). If there were no lymph spaces, these cells could not get any food. The lymph bathes the cells, and the cells absorb

what they want from the nourishing fluid. The red corpuscles bearing the oxygen cannot pass through the capillary walls. Oxygen, being a gas, readily passes through the walls and reaches the cells through the lymph in the lymph spaces. Carbon dioxid passes back through the capillary walls directly into the blood and is taken to the lungs. You will soon learn what becomes of the other waste materials.

Need of Lymphatics. — *If when the plasma passes into the tissues none of it returned to the blood vessels, the blood would soon become thick for want of the liquid plasma, and the tissues would be swollen.* Very little of the lymph can soak back directly into the blood tubes because of the greater pressure in the blood tubes, brought about by the heart's continual pumping. The lymph contains waste material, which must be removed, and much unused food which nature, like an economical housekeeper, will offer to the tissues again. *The vessels that take the lymph back into the blood are called lymphatics.* See Fig. 90.

The Lymphatic Circulation (Fig. 89). — The lymph flow, unlike the blood flow, begins at a certain place and ends at another certain place. The blood flow, on the contrary, does not begin nor end, but makes a never ending circle. The countless *lymphatics begin, with open ends, in the lymph spaces* between the cells (colored Fig. 6). Smaller lymphatics unite to form larger ones until finally they all unite into two large ones that empty into two large veins under the collar bones, near the neck. The one that empties under the left collar bone is the largest lymphatic in the body, being about the size of a goose quill. It is called the *thoracic duct* because it goes up through the thorax just in front of the spinal column (colored Fig. 15). The other large lymphatic at the neck

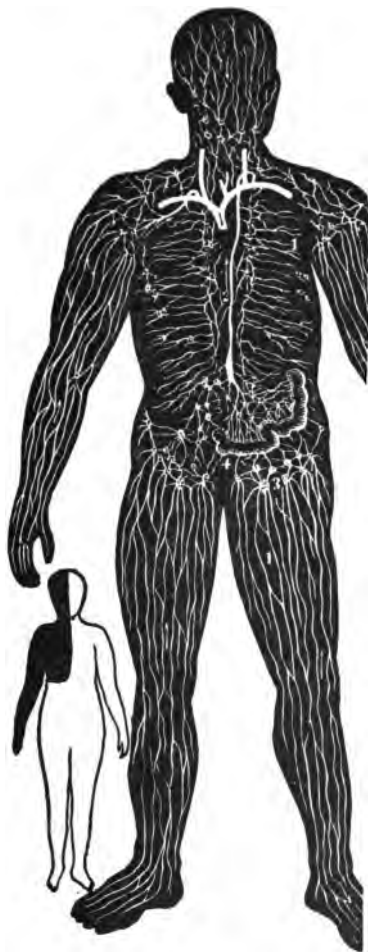


FIG. 89.—THE LYMPHATIC SYSTEM, showing the lymphatics, the glands in the groins and armpits, the lacteals which absorb the fat from the intestine, and the thoracic and right lymphatic ducts emptying into veins near the neck. (Compare with colored Figure 15.) The small diagram shows the two parts of the body drained by the two ducts.

is called the *right lymphatic duct* (colored Fig. 15). It receives lymph from the lymphatics that drain the right side of the head, neck, and chest, and the right arm (see Fig. 89). The thoracic duct receives the lymph from all the rest of the body. See smaller diagram of Figure 89.

In persons with the *dropsy*, the lymph accumulates in the lymph spaces and is not drained away by the lymph flow. Farmers often drain marshy land with underground pipes or tiles; if the tiles fail to work, the land becomes very wet and soggy. The tissues of a person with dropsy may be compared to such land. As in such land, the lowest part would become soggy first, so dropsy usually shows itself first by swelling of the feet and the leg below the knee.

There is a set of lymphatics called *lacteals*, situated in the abdomen, which have the function of absorb-

ing digested fats from the intestine (see colored Fig. 15, Fig. 89, also p. 161).

What makes the Lymph Flow ? — The heart does not, for its pressure is not transmitted beyond the blood tubes. There is no lymph heart, for every minute part of the body has been dissected numberless times, and no pumps have been found except those in the heart. It would not be possible to cause the lymph to flow if it were not for the valves in the lymphatics. These are so numerous that a lymphatic has a beaded appearance ; they all open the same way (see colored Fig. 13). Hence the *successive*

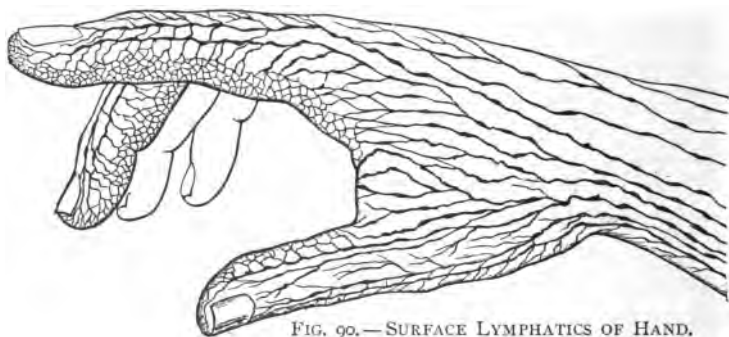


FIG. 90.—SURFACE LYMPHATICS OF HAND.

pressures of a working muscle move the lymph forward in the lymphatics in the same way that the blood is moved forward in the veins (p. 87). Likewise, *if the body is pressed upon or shaken*, as when riding a trotting horse, or in a jolting vehicle, the lymph is moved beyond the valves at every jolt. This aids the muscles in causing the lymph to circulate. Without exercise the lymph stagnates, and the body becomes poisoned by its own wastes. When, by exercise, the lymph is promptly returned to the blood, poisonous waste materials are removed, and do not interfere with the free, healthy life of the cells.

The Lymphatic Glands and their Use (colored Fig. 13). — These glands are kernel-like enlargements along the lymphatics, and they contain a great many lymph cells, which *purify the lymph as it passes through them*. The lymphatic glands are especially numerous in the armpits and the groins (see Fig. 89). The cells in the lymph glands multiply, and some of them are carried by the lymph into the blood *to become those remarkable little bodies, the white corpuscles*.

The spleen is located just under the diaphragm, at the left of the stomach; its color is purplish red. By some physiologists it is classed with the lymph glands. If the white corpuscles may be compared to policemen that arrest intruders and enemies of the body, the spleen may be compared to police headquarters. If the white corpuscles are compared to scavengers, then the spleen corresponds to the dumping and burning ground of the health department; for *impurities are destroyed there, even the worn-out red corpuscles being broken up and destroyed in the spleen*. It is not surprising that when the body is filled with malarial or other poison, the spleen sometimes becomes of an enormous size. White corpuscles are probably formed in the spleen; the old white corpuscles are destroyed chiefly in the smaller lymph glands.

HYGIENE OF THE CIRCULATION

The importance to health of a good circulation may be judged from accidents that have happened to a limb. All of the nerves that supplied the limb of an animal have been cut. The limb was paralyzed, but the circulation was active, the hair and nails continued to grow, the limb remained warm, and the only change besides paralysis was

some loss in size. In the case of another limb, however, in which the arteries had been cut and the nerves left uninjured, it was found that the limb soon became cold ; in a few hours it was black, and in a short time the flesh began to fall away. The limb had died. The Bible says the blood is the life.

How the Muscles help the Circulation. — The imperative need of muscular exercise to keep the body sound exists because of the lack of other means to cause movement in the veins and lymphatics. The pressure from the heart extends through the arteries and capillaries, but soon disappears in the veins, and of course the heart beat does not affect the lymphatics at all. (Repeat the explanation already given, of how a contracting muscle, with the aid of the valves, causes the blood in the veins to flow only one way ; it has a similar effect on the lymph.) Good food, pure air, and plenty of exercise are necessary for healthy blood. Many so-called “blood purifiers” are advertised to entrap the ignorant. It is impossible to imagine how “blood purifiers” can aid the blood. *The blood is purified not by putting anything into the blood, but by getting something out. The way to get the waste material out of the blood is by exercise* vigorous enough to cause deep breathing, active perspiration, and a free, rapid circulation ; the lungs, the skin, and the kidneys all send out impurities brought to them by the blood.

The one great hygienic effect of muscular exercise is an *active circulation*, and from an active circulation *nine chief effects* may be traced. The effects upon the body will be given in order, beginning with the surface — skin, fat, muscles, bones ; and the effects upon the internal organs are given in order of position, beginning with the highest — brain, lungs, heart, digestive organs.

The Nine Effects of an Improved Circulation. — 1. *The skin* is made fresh, pink, and smooth from the flushing of the capillaries; it is purified by the perspiration and the renewal of cells.

2. If *the fat* is too great in amount, it is burned up; if it is too small in amount, the better nourishment brought by the blood increases it.

3. *The muscles* are better fed (colored Fig. 12) and grow firm, strong, and large.

4. *The skeleton* is held in proper position by the stronger muscles, and deformity is prevented.

5. *The Brain.* The pure, fresh blood, loaded with oxygen from expanded lungs, flushes every capillary of the brain, clears the mind, and doubles or trebles its power to work.

6. *The lungs* are expanded if the exercise be rapid and vigorous.

7. *The Heart.* Every contracting muscle aids the heart in its work.

8. *The Stomach.* Exercise burns up the food and increases the appetite.

9. *General Effects.* Exercise moves the stagnant lymph and renews the lymph in every tissue; it promotes good humor, decreases loafing, cigarette smoking, gossiping, and other vices.

When the red corpuscles of blood are too few the person is said to have *anē'mia*. Children with a tendency toward thin blood, or anemia, are likely to be pale, to catch cold readily, and to have flabby muscles and a poor appetite. This may be the result of naturally delicate health, or of improper bringing up. In either case it is absolutely necessary that the child have plenty of fresh air, sunshine, and sleep, with gradually increasing muscular exercise.

The custom that prevails in some schools of giving work that requires children to study at night, is a very bad one. A poorly ventilated schoolroom or sleeping room is dangerous to the health of children. Anemia may also appear with developing girls and fast-growing boys just entering the high school. Harmonious development of both mind and body is needed, not merely the cramming of the mind with books. Unfortunately, parents often, from lack of judgment or from vanity, spur their weak children on to exclusively mental effort, that they may take first places at school. The teacher or the physician should persuade parents to take such a pupil away from school for a year or more, that the brain may have rest. Cold baths, trips to the country, suitable diet, outdoor games, the preservation of childlike feeling, and the avoidance of exciting novels and fashionable follies are more needed than education or drugs in such cases. Sometimes factory women are anemic because they do not eat enough of foods rich in nitrogen. They wrongly think that such food as eggs, cheese, and meat are too expensive. Factory girls and shop girls whose work requires them to stand all day, and who live at a long distance from their work, should not walk home at night to save car fare.

The Effect of tobacco upon the heart, especially if cigarettes are used, is sometimes to cause attacks of irregular beating; the heart flutters faintly for a while, then palpitates strongly, then flutters again. This trouble is called tobacco heart, or trotting heart.

Effect of Alcohol upon the Circulation. — After a person has taken an alcoholic drink his face and skin are likely to become flushed, and perhaps his heart beats faster. Most investigators have found that the *alcohol itself does not directly increase or strengthen the action of the heart.*

Hence it is wrong to call alcohol a heart stimulant. The lively muscular movements a man may make when his judgment is slightly clouded by alcohol and the general derangement of the body by the alcohol may cause his heart to beat faster. The flushing of the skin is believed to be due to the relaxing effect which alcohol has upon the little muscle fibers in the walls of the blood vessels. The narcotic effect of alcohol is much more powerful than its irritating or stimulating effect. The effect of alcohol in causing fatty degeneration of the muscles often weakens the heart and other blood vessels.

PRACTICAL QUESTIONS.—1. Through what kind of skin do the blue veins in the wrist show most plainly? Because people who do no physical labor often have such skins, they are sometimes termed “blue-blooded aristocrats.” Would you prefer to belong to the “blue-blooded aristocracy” or to the red-blooded aristocracy? 2. Which is more compressible, a vein or an artery? Does a tight garter interfere more with the flow of blood to the feet or from the feet? 3. Why are those who take little exercise likely to have cold feet? (p. 98.) 4. What is the purpose of a linen cuff? What is the purpose of a linen collar? Why is it unnecessary to have a collar as high in front as behind? What two evil effects to the neck result from such a collar? 5. Where does the so-called venous blood flow through an artery? (p. 91.) 6. What vein begins and ends in capillaries? (The portal vein, p. 91.) 7. To what purifying organ, after leaving the lungs, does the heart send part of the blood before the blood has had a chance to become impure? (Colored Fig. 2.) 8. What keeps the blood moving between the beats of the heart? (p. 82.) 9. Why does rubbing wear out a shoe, although it causes a corn to grow on the skin? Is the pressure of a tight shoe constant, or does it change at every step? How would this affect circulation and nutrition in the toe? 10. Riding in a jolting vehicle assists especially what part of the circulation? (p. 96.) 11. Why is it best that the blood flows slowly through the capillaries? 12. What cells need no lymph spaces in order to get their nourishment? (Fig. 84.) 13. How may internal organs be relieved of congestion? How may the skin be caused to glow with blood? 14. Why does a boy who smokes have less prospect for success in life than he would have if he did not smoke?

CHAPTER VI

THE RESPIRATION

The Nature of a Breathing Organ.—The blood sent to the tissues soon becomes dark because of loss of oxygen and absorption of impurities. It is then carried through the heart to the organ which has the function of supplying oxygen and giving off carbon dioxid. In some small animals, as the ameba and the earthworm, the surface of the body suffices for breathing. *But large animals with many deep-seated and hidden cells require a breathing surface greater than the area of the skin, covered by cells of specialized activity. This is supplied by having the oxygen-absorbing surface inside of the body, and by having it provided with folds and tubes and minute cavities of great complexity.* It is estimated that if the lungs of a man were unfolded and all their tubes and cavities spread upon one surface, an area of more than one hundred square feet (or ten feet square) would be covered. This immense surface is exposed to the air at every full breath. Many muscles and bones, without which the lungs would be helpless, have a part in breathing.

Each **respiration**, or breath, consists of the passing in of the air, or *inspiration*, sending it out, or *expiration*, and a *pause* after one but not both of the other stages.

The Air Passages.—The air usually passes in at the nose and returns by the same way, except during talking or singing. If you look in your mouth with a mirror (Fig. 91), you will see, at the back part, an arch which is

the rear boundary line of the mouth. Just above the arch is likewise the rear boundary line of the nasal passages. The funnel-shaped cavity beyond, into which both the mouth and nasal passages open, is called the *pharynx* (far'inks), or throat (see Fig. 91, also Fig. 108). Below, two tubes open from the pharynx. One is the *trachea* (trā'kea), or windpipe, the other is the *esophagus*, or gullet.

At the top of the trachea is the cartilaginous *larynx*, or voice box. If the finger is placed upon the larynx, or Adam's apple, it is plainly felt to move up and down during the act of swallowing. The opening into the larynx is provided with a lid, the epiglottis also consisting of cartilage. The larynx will be described more fully in treating of the voice.

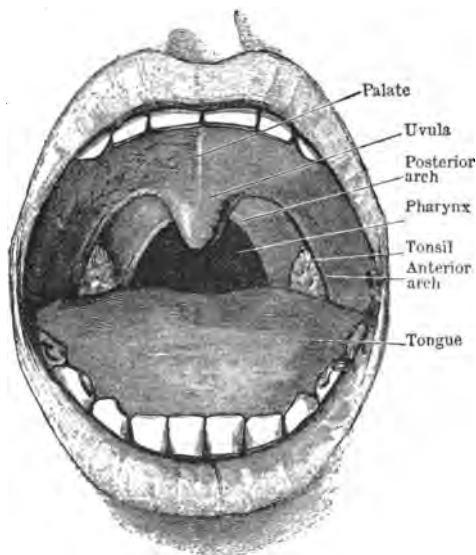


FIG. 91.—OPEN MOUTH, showing palate and tonsils.

Just below it comes the trachea proper, which is a tube about three fourths of an inch in diameter and about four inches long (Fig. 92). It consists of hoops of cartilage (Fig. 92) which are not complete circles, but are shaped somewhat like the letter C, being completed at the rear by involuntary muscular tissue, whose function is to draw the ends together at times (for instance, during coughing) and reduce the size of the tube. The

function of the hoops of cartilage is to keep the windpipe open at all times. If it should be closed by pressure, life might be lost. You may feel these rings of cartilage in the neck.

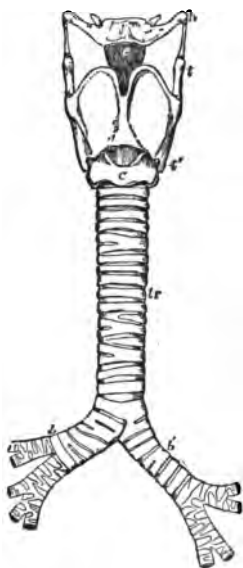


FIG. 92.—THE TRACHEA.

h, hyoid bone; *e*, epiglottis;
t, t', *c*, cartilages of larynx.

called a *lobule* (Fig. 93), into which so many dilated sacs, called *air cells*, open, that the walls of the terminal chamber, or lobule, may be said to consist of tiny cups, or air cells, placed side by side. The lobules, or clusters of air cells, are chiefly near the surface of the lung. (The word "cell" is here used in its original sense to denote a cavity or chamber, and not in the sense of a protoplasmic cell.)

The lower end of the trachea is just behind the upper end of the breastbone; there it divides into two large tubes. These subdivide into a great number of smaller branches, called *bronchial tubes*. Cartilage is found in the walls of all but the smallest of the tubes. The subdivision continues, somewhat like the branching of a tree, until the whole lung is penetrated by bronchial tubes.

Each tiny tube finally ends in a wider funnel-shaped chamber

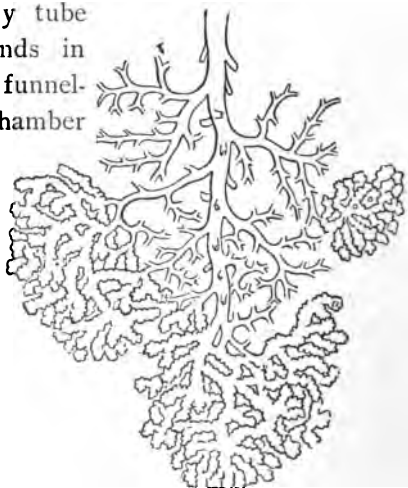


FIG. 93.—A LOBULE OF THE LUNGS, showing air tubes and air sacs.

The *air cells are elastic* and enlarge by stretching as the chest expands; hence, the cells must have many of the yellow elastic fibers of connective tissue in their walls. They are lined with thin epithelial cells through which *oxygen and carbon dioxid are exchanged*. In the partitions between the air cells there is *a network of capillaries*. The dark red blood comes into these capillaries from the pulmonary arteries, and is changed to a bright red by the time it leaves them to enter the pulmonary veins (see colored Fig. 7).

Most of the **mucous membrane lining the air passages** has a surface layer of ciliated cells. *Cilia are tiny, hair-like projections* (Fig. 94) which continually wave to and fro, the quicker stroke always being outward; for their function is to remove particles of dust and germs that may find entrance to the air passages. When the mucus containing the dust is raised nearly to the larynx, it may be thrown out by coughing. *Near the opening of the nostrils are placed many ordinary hairs*, hundreds of times larger than cilia, through which the air is strained as it enters the nose.

The Lungs. — The entire *chest cavity* is occupied by the lungs except the space occupied by the heart, the larger blood vessels, and the gullet. The right lung has three lobes, or divisions, and the left lung has two lobes. The lungs are light pink in early life, but become grayish and darker as age advances. This change is more marked in those who dwell in cities, or wherever the atmosphere is smoky and dusty. The lungs are covered and inclosed by a smooth membrane called the *pleura*. This membrane

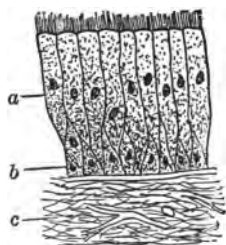


FIG. 94. — CILIATED CELLS, lining the air passages.

turns back and lines the chest wall, so that when the chest expands, the two sleek membranes glide over each other with far less friction than would be the case if the lungs and chest wall were touching.

Experiment 17. The fresh lungs of a beef when thrown upon water will float. If the air is forced into the lungs

through a tube inserted in the wind-pipe, they will swell. Just so soon as one ceases to blow into the lungs, they begin to contract because of the elastic walls of the air cells.



FIG. 95. — VERTICAL SECTION OF TRUNK, showing diaphragm, cavities of thorax, and abdomen.

The Respiratory Muscles. — The chief breathing muscles are the *diaphragm* (see Figures 95 and 96), the muscles *forming the abdominal walls* (see Figures 64 and 65), and *two sets of short muscles* (an internal and an external set) *between the ribs*. You may have noticed these muscles when eating pork ribs. The *diaphragm*, which is shaped like a bowl turned upside down, rounds up under the base of the lungs somewhat like a dome and separates the chest from the abdomen. Its hollow side is toward the abdomen and its edges are attached to the lowest ribs and the vertebra of the loins. Inspiration

is brought about by the rising of the ribs and the descent of the diaphragm. Expiration takes place when the diaphragm is raised, and the ribs descend. See Figures 95 and 96.

Observation of a Breath.— Empty your lungs as completely as possible, and then place one hand on each side of the body with the thumbs backward and the finger tips touching at the waist in front. On taking a deep breath you feel the chest enlarging at the sides and in front. How

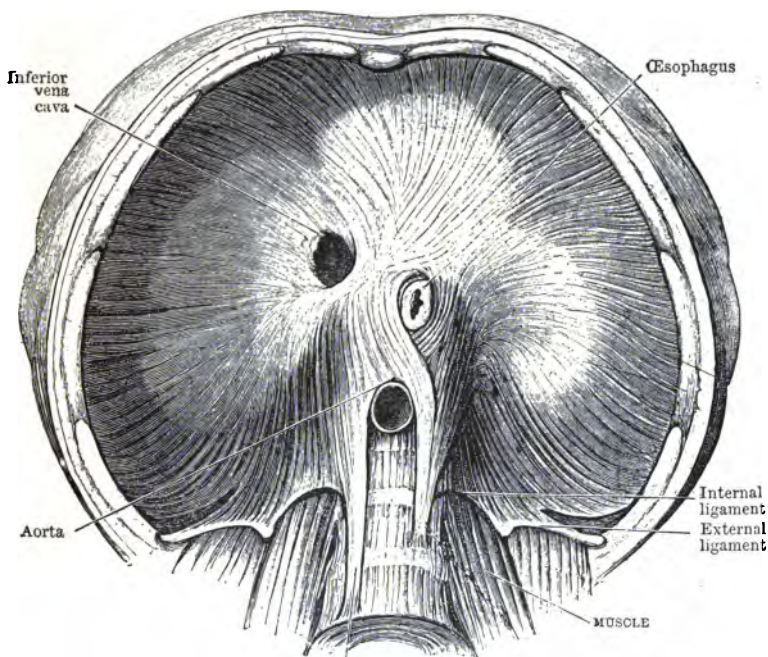
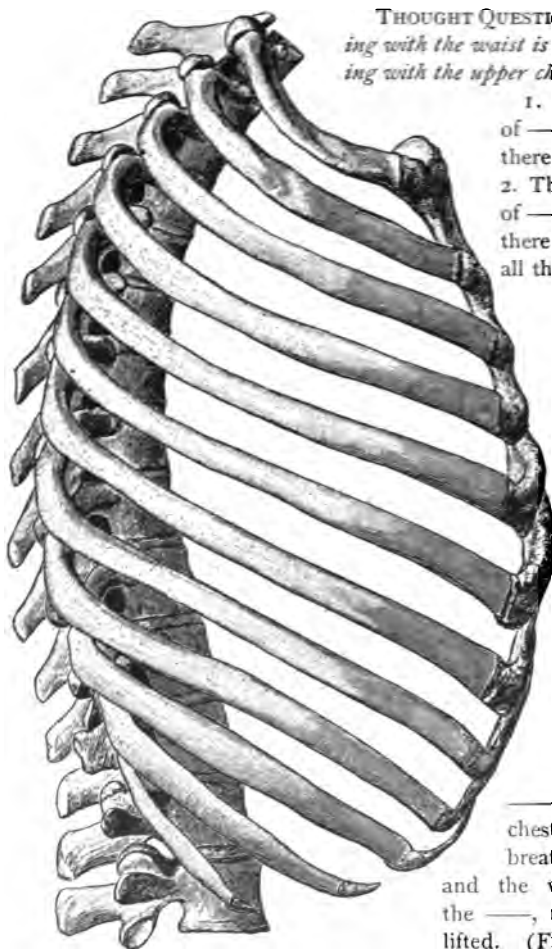


FIG. 96.—DIAPHRAGM (or midriff), seen from below. (Cunningham.)

The central portion (light) is tendinous. As the diaphragm descends, it acts like the piston of a great pump and the blood is forced up through the vena cava, and the lymph through the thoracic duct (colored Fig. 15).

far apart are your finger tips now? Expel the breath, and the fingers come together again. Take another breath with the hands on the abdominal walls and notice how they move during inspiration and expiration. The number of breaths is about eighteen per minute—one fourth the number of heart beats.

Experiment 18. Study the breathing of human beings, cows, and other animals, noticing the manner of breathing and counting the number of breaths per minute.



THOUGHT QUESTIONS. — *Why breathing with the waist is easier than breathing with the upper chest.*

1. There are two pairs of — ribs below, while there are none above.
2. There are three pairs of — ribs below, while there are none above, but all the ribs of the upper chest are — ribs.
3. The lower of the joints between the seven pairs of true ribs and the sternum are more flexible than the upper joints because —. (Observe the joints in Fig. 98.)
4. The walls of the waist swing — and —, while the walls of the upper chest must move — and —.
- 5.

The bones of the — rest upon the upper chest. In upper chest breathing their weight, and the weight of both of the —, must, therefore, be lifted. (Fig. 33.) Test by

FIG. 97.—THE CHEST, from the right side. trying it.

Experiment 19. Let the teacher mark the beginning and end of a minute by tapping a bell. Count the number of

times you breathe per minute while sitting ; also the number just after the school rises and takes vigorous gymnastic movements for five minutes.

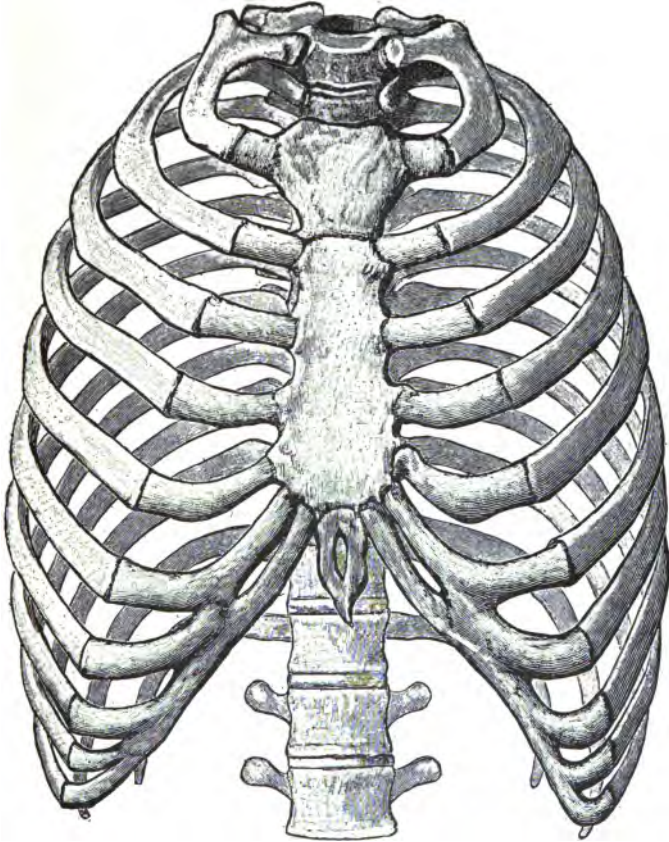


FIG. 98.—BONES OF THE CHEST, seen from the front.

Inspiration. — When the diaphragm contracts, it flattens and descends, and the lungs descend with it, thus lengthening the chest from top to bottom ; at the same time the ribs are raised upward and outward (Fig. 99) by the contraction of the outer set of muscles between the ribs.

Thus the *chest is made longer, broader, and deeper from front to back*. The lungs expand when the chest expands, and the air rushes in. Why is this? The lungs contain no muscles and cannot expand themselves; the air cannot be pulled in, for its parts do not stick together. The explanation is that the air has weight. The atmosphere has a height of many miles, and the air above is pressing on that below. When the chest walls are raised, there would be an empty space or vacuum between these walls and the lungs did not the pressure of *the outside air push air through the windpipe into the lungs and expand them*.

Expiration.—In very active breathing the abdominal walls actively contract so that they press strongly upon the diges-

tive organs, which in turn *press the diaphragm up*. *The ribs are also drawn down and in*. Thus the chest becomes smaller and forces the air to flow out through the windpipe. Draw in the abdominal walls with a jerk; what is the effect upon the breath?

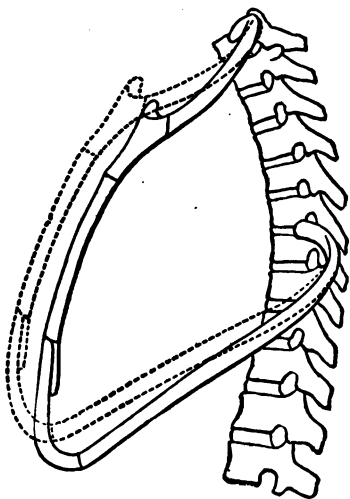


FIG. 99.—BLACKBOARD SKETCH, to show how the chest is expanded when the ribs move upward and outward.

Why the Diaphragm ascends during Expiration.—Pupils sometimes get the idea that when the diaphragm relaxes it springs up into place. The diaphragm has no more elasticity than a piece of cloth. It relaxes after the breath is drawn in, and it would fall of its own weight if it were not supported by the organs be-

neath it. In reality, these organs have been compressed, and the abdominal walls which contain them have been

slightly stretched by the descent of the diaphragm, and when it relaxes, it *is lifted by the expansion of these organs, and by the pressure from the pulling in of the elastic abdominal walls* (see Fig. 95).

Why Expiration in Quiet Breathing is Passive. — In ordinary quiet breathing the breath is actively inhaled, but is exhaled without muscular effort. This is because during inspiration the air cells are stretched, and the cartilages connecting the ribs with the sternum are slightly bent. The straightening of the cartilages causes the ribs to be lowered. This, with the contraction of the stretched air cells, forces the breath out (Figs. 97, 98).

Experiments. — 20. Try breathing with (1) muscular inspiration and passive expiration; (2) muscular expiration and passive inspiration; (3) with both motions muscular. 21. Finally, cease to notice your breathing for several minutes, and then notice it again without disturbing it, and see which of these three methods you are using.

Chest Breathing, Abdominal Breathing, Full Breathing. — These forms depend upon whether the breathing is carried on by using the muscles of (1) the chest, (2) the abdomen, or (3) both (see Figs. 100, 101, 102). There has been much debate among physicians, surgeons, and singers as to which of these methods is best. Probably this question would not have been raised but for the confining and deforming effect of clothing upon the waist. *Full breathing is used by children of all races, by both men and women of wild tribes, and by men and children of civilized countries.* It is undoubtedly the natural way, as well as the easiest and most effective way. Breathing with the upper chest is exhausting because of the stiffness of the upper part of the bony cage (see Fig. 98); for it is inclosed by true ribs fixed to the breastbone by short carti-

lages. The ribs in the waist (Fig. 97) are either floating in front or fixed by long cartilages to the ribs above. In



FIG. 100.

FIG. 101.

FIG. 102.

Fig. 100. — Female figure encased in corset. Expansion at the waist is here impossible and the breathing is called "collar-bone breathing."

Fig. 101. — Male figure. Here, owing to pressure of clothing and faulty position, expansion of chest is hindered and breath is taken by the "abdominal method."

Fig. 102. — Figure properly poised and free. Here the entire thorax can move freely, and natural breathing is the result. (For blackboard.)

pure abdominal breathing the diaphragm must contract more than in full breathing in order to descend, because its edges have been drawn together and fixed by binding the ribs at the waist. In full breathing the floating and false ribs at the waist (five pairs in all) float in and out as nature provided. As they move out, this broadens and deepens the chest, and aids the flattening of the diaphragm by moving its edges farther apart.

Experiment 22. Place your hands upon the sides of your waist, and while breathing deeply, notice whether *the ribs move in and out*. Many people have lost this power for life by wearing belts or other articles of clothing of such a size as not to allow for expansion. Their vital powers and endurance are crippled. It usually proves to be a permanent loss (see Figs. 110, 111).

THOUGHT QUESTIONS. — Write *I*, *E*, or *IE* after each word in this list according as inspiration, expiration, or both are involved in the action. Sighing, sobbing, crying (of a child), coughing, laughing, yawning, sneezing, hiccoughing, snoring.

Three Experiments on Expired Air. — 23. If you breathe on a cold window pane, you notice that *the glass soon becomes covered with water*. 24. If you breathe through a tube or straw, or the hollow stem of a weed, into a bottle of clear limewater (Fig. 103), *the water soon has a milky appearance*; only carbon dioxid has this effect. Limewater may be obtained from the drug store, or it may be made by pouring water upon a lump of unslaked lime and draining it off when the lime has settled. 25. If you breathe for several minutes upon the bulb of a thermometer, even on a cold day, *the mercury will rise rapidly*. Thus three things are proved; water and carbon dioxid are given off from the lungs, and carry much heat from the body with them.



FIG. 103. — BREATHING THROUGH LIMEWATER.

Difference between Inspired and Expired Air. — The air entering the lungs consists of about one fifth oxygen and four fifths nitrogen. This nitrogen is of no use to the body, and is exhaled unchanged. *About one fourth of the oxygen inspired is taken up by the blood, and carbon dioxid sent out in its place* (see colored Fig. 7). The oxygen absorbed by the blood amounts to one and four fifths pounds each day. The inspired air contains a small amount of *watery vapor*; the expired air contains much more. About half a pint of water is given off through the lungs in a day. Minute quantities of injurious animal

matter are also given off in the breath from even the soundest person, while one with decayed teeth, catarrh, indigestion, lung troubles, or other unsoundness gives off still more of this material. When many people are assembled in a badly ventilated room, the amount of injurious animal matter in the air is much increased, and it is called "*crowd poison*." Its odor is strong and repulsive to one who just enters the room, but the sense of smell becomes dull to it in a few minutes. It would seem that nature gives a fair warning against harm ; but if we disregard the warning, it soon ceases.

Experiment 26. Fill a fruit jar with water and take it into a room containing many people. Pour out the water. Pour in two tablespoonfuls of clear limewater and shake. If the limewater turns milky, the ventilation is bad.

People who are really Unclean. — Air once breathed is impure. It is just as unfit to enter our bodies as muddy

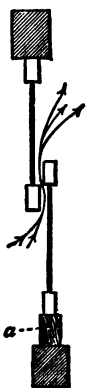


FIG. 104. — Inlet without a draft.
a, strip of wood.

water or decayed food. Yet many who call themselves cleanly and refined, and will not allow a speck of dirt to remain on their clothes, nor use a spoon just used by another, do not object to breathing into their lungs, over and over again, the cast-off air from the lungs of others. If a window is opened for ventilation, they are horror-struck for fear of drafts. Drafts are injurious only to persons perspiring, or to those who have coddled the skin by continually overheating it. There are thousands of schools, churches, and theaters all over the land which reek daily with the malodorous particles from the lungs of their occupants. Although the air in them is odorless to those who occupy

them, it is disgusting to any one who enters from the fresh air. Figure 105 shows a ventilated schoolroom.

Dust is injurious, and gradually weakens the lungs of those who breathe it. Intelligence and common sense are necessary to prevent it from accumulating in the house. The chief purpose of house cleaning should be not only to remove bits of paper from the

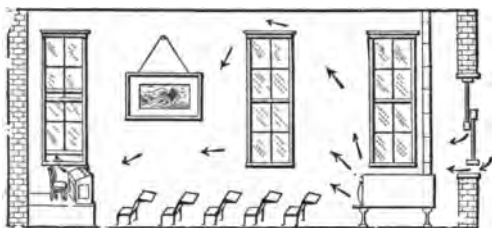


FIG. 105. — CORRECT VENTILATION OF SCHOOLROOM.

How are the inlet and outlet situated with reference to the stove?

floor, which do no harm even to the shoes, but *to remove impurities from the air. It does no good to stir up the dust and allow it to settle down again.* In many houses dust is thus allowed to accumulate for months. Experiments show that dust and germs floating in the air are not diminished to a great extent by a gentle draft through the room. The windows must be open and sweeping done in the direction of the air currents; the windows should be *left open for a long while after the sweeping.*¹ A windy day is best for sweeping. With all precautions some dust may settle down. This should not simply be stirred up again with a feather duster, but *the dusting should be done with a damp cloth.* Carpet sweepers, but never brooms, should be used upon carpets. Carpets and lace curtains are truly dust traps, in which dust

¹ The habit some housekeepers have of buying furnishings and bric-à-brac for the home until it looks like a retail store or junk shop, makes it almost impossible to clean their houses. A few articles, carefully selected, adorn a home more than many bought at random, and they do not litter the house and serve as traps for dust.

will accumulate without limit. Those who value the health will not use them, at least in bedrooms. Though linoleum,

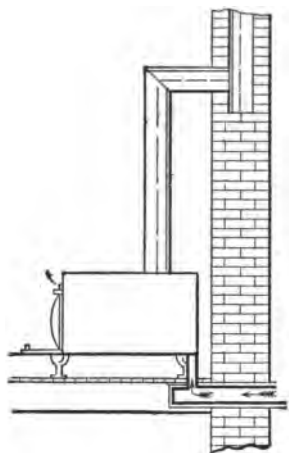


FIG. 106. — The air enters through a special inlet and is warmed as it passes through hood surrounding the stove.

bare floors, oiled and painted floors, may not look so comfortable, they bring far more comfort in the end. *The weakening effect of ordinary dust is one of the chief causes of lung diseases*, and prepares a fertile soil for the consumptive germ. The sputum coughed up by consumptives falls upon the floor or street, soon dries, and the germs are driven about by the wind. In many cities there is a law against spitting in public places, and the streets are flushed with water before they are swept.

Ventilation presents no difficulties in the summer time or in warm climates. The reason that it is a difficult question in cold weather is because the air furnished must be not only pure, but warm. *Heating with hot air*, by which system pure air is passed over a furnace and fresh air constantly admitted, is a good method (Figs. 106, 107). Heating by *hot water* circulating in pipes, or *by steam*, gives no means of introducing fresh air, and is likely to cause worse ventilation than any other method.

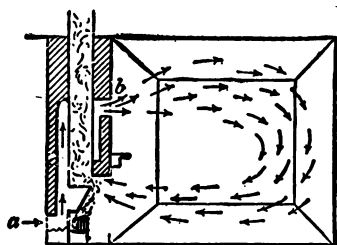


FIG. 107. — A passage behind a fire-place, or grate, in which the air is warmed as it enters.

The radiators for both of these systems should stand close to windows or other fresh-air inlet, that the air may be heated

as it enters ; and the outlet for air should be farthest from the radiators. The same rules apply to heating by *stoves*. Heating by *fireplaces* (Fig. 107) is the most healthful of all methods, for there is a constant removal of air through the chimney, and this air will be replaced ; even if all doors and windows are closed, it will come in through tiny cracks. Fireplaces, however, do not afford sufficient heat in severe climates. Stoves are not as healthful as fireplaces, for there is not so much air removed through the pipe as through the chimney. Be prepared to draw Figure 105 on the blackboard, and explain it to the class.

Experiments. — 27. Dangle a bit of paper by means of spider web from the end of a walking stick or ruler. Hold it by the windows or openings intended for the entry and exit of air and test if the air moves as desired. 28. The whole class may rise and test cracks around every window and door. Wherever the air feels cold to the hand the air is entering.

Reasons for breathing through the Nose (Fig. 108). — (1) The many blood vessels in the mucous membrane lining the nasal passages and covering the thin, platelike bones (see Fig. 164, also Fig. 165) projecting into the nasal passages so *heat the air* that it does not

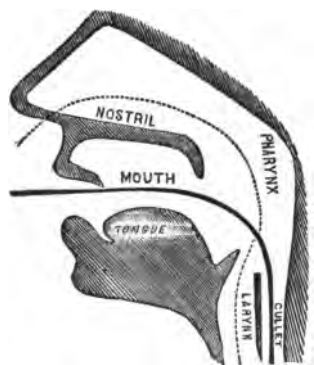


FIG. 108. — BLACKBOARD SKETCH.

irritate the bronchial tubes. The blood in the mucous membrane heats the air as hot-water pipes heat the air of a room. The air passes more gradually through the small nose than through the large mouth. (2) *The hairs in the nostrils strain the air* and catch dust ; the cilia of the nasal pas-

sages also do this. (3) A mouth breather often *swallows food before chewing it sufficiently*, because he cannot hold his breath longer. (4) The nasal mucous membrane of an habitual mouth-breather *dries and shrinks* and obstructs the circulation, bringing on *catarrh of the nose*. (5) Mouth breathing causes an *unpleasant expression of countenance*



FIG. 109. — Facial expression in mouth breathing, and breathing through the nose.

(see Fig. 109). (6) The breath does not come through the nose as quickly as through the mouth; the *lungs are kept more expanded*, and one does not get "out of breath" so quickly. (7) *The voice of the mouth breather has a hard twang*, not a full, resonant tone as when the nostrils are open. (8) *Flavors and odors are better*

appreciated. Sometimes the sense of smell is almost lost by mouth breathers.

If one cannot breathe through the nose, there is probably some obstruction, and a physician should be consulted.

Diseases of the Respiratory Organs. — *A cold, or catarrh, is an inflammation of a mucous membrane.* If the inflammation is in the nasal passages, it is called a *cold in the head*; if it is in the pharynx, it is called a *sore throat*; if it is in the larynx, or voice box, there is *hoarseness*; if it is in the bronchial tubes, it is *bronchitis*; finally, if it is in the air cells, it is *pneumonia*. If the air is cut off from access to the air cells, there is an attack of the painful disease called *asthma*, which is accompanied by a feeling of suffocation. Some believe that asthma is caused by the mucous membrane lining the finest bronchial tubes becoming inflamed and swollen, and closing the tubes; others think that the muscles in the large bronchial tubes contract and close the

tubes. *Pleurisy* is inflammation of the pleura. If much fluid forms between the pleuras, the inner pleura may press upon the lungs and interfere with breathing.

Alcohol not only weakens the blood vessels near the surface but the blood vessels in general. Weakened and congested blood vessels in the lungs make them more liable to pneumonia and other congestive diseases. Continual congestion causes an abnormal growth of connective tissue fiber in the walls of the cells. This interferes with the exchange of carbon dioxid and oxygen.

Tobacco. — It is often asked why cigarettes are so much more injurious to the health than pipes and cigars. The nature of the paper of cigarettes and various other absurd reasons have been assigned. The true reason is that the cigarette smoker usually inhales the tobacco smoke. Cigar smoke drawn into the lungs would usually be coughed up, but cigarette smoke is weaker — it is so weak that the smoker is not content simply to absorb the nicotine through the mucous membrane of the mouth. He draws it into the lungs. As the *surface* of the lungs is *a hundred times greater* than the surface of the mouth, and *its lining much thinner*, cigarette smoking is far more injurious than cigar smoking.

Prevention of Colds and Other Respiratory Diseases. — A weak or deranged circulation allows congestion or swelling of the blood vessels to occur in some weak part of the mucous membrane. The capillary walls become injured by the pressure, and blood escapes and stagnates in the tissues, causing inflammation. The best way to prevent congestion is to *strengthen the circulation and the nerves that control it, so that the circulation will not be deranged by every slight strain or exposure*. Coddling, or overheating the body and protecting it too carefully, often leads to

colds and bronchitis. Clothing may flatten the chest and deform the waist (Figs. 110, 111, 112). Bracing the skin

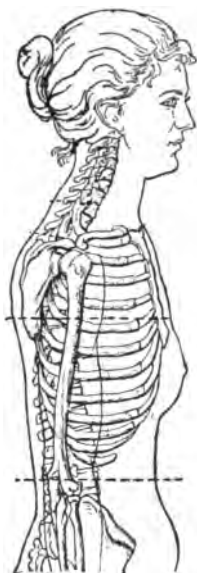


FIG. 110.

FIG. 110. — Flattened chest and sunken abdomen from wearing tight clothing since the age of fourteen.

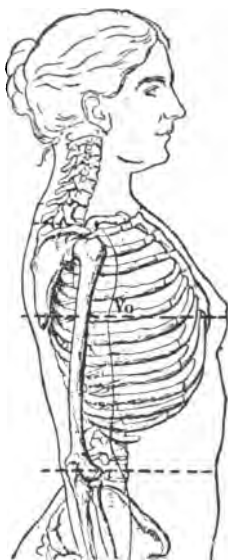


FIG. 111.

FIG. 111. — A natural woman. Women with forms like Figure 110 often walk with bodies bent forward to hide the prominent abdomen.

is the best protection against taking cold. Because of dress, and by constantly living in houses, the average civilized man seems to have lost the power which the skin in savage races possesses of reacting promptly to changes of temperature.

Moritz says that it is astonishing to see how many people coddle and weaken their bodies in the most terrible way, simply because the sensation of warmth is pleasanter to a weak person than that of cold.

Wearing clothing that is too heavy, sleeping on feather beds, or living in a house heated to a higher temperature than seventy degrees are ways of weakening the body. Cold baths, clothing just warm enough to be comfortable, living much in the open air, harden and strengthen the body. Pneumonia, consumption, and other serious lung diseases usually begin with a cold, cough, or bronchitis. This furnishes a weighty reason for so training the body as to overcome a tendency to the lesser troubles. People

who take reasonable care of themselves do not have colds so often as once a year.

The cold begins in the weakest spot, and with some people this is always the same part ; for instance, the head. *Many people suffer constantly from cold feet*, which are either moist or dry ; this may bring on chronic bronchitis that cannot be cured until the circulation in the feet is strengthened and warmth is

restored. This may be done by bathing them in cold water, changing the hose once or twice a day, or rubbing them

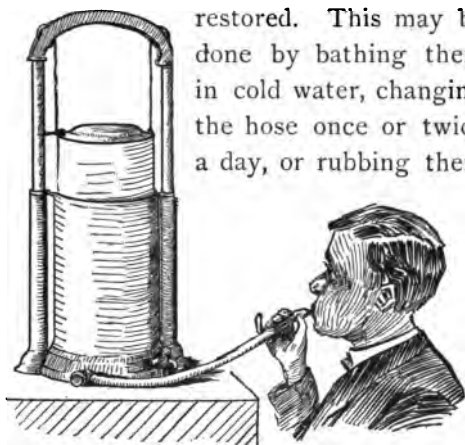


FIG. 113. — SPIROMETER for testing the breathing. Average man blows 230 cu. in.; woman, 170 cu. in.

Average lung contains 330 cu. in. of air; 100 cu. in. (*residual air*) cannot be sent out; beginning with the lungs at rest, 100 cu. in. (*reserve air*) may be expelled; 30 cu. in. (*tidal air*) flows in and out in quiet breathing; at the end of a quiet inspiration, 100 cu. in. (*complemental air*) may still be inhaled.

accompanied by pain, do not attract their attention. *Singing* is a good preventive of lung diseases. When the lungs are congested and diseased, the patient may with advantage take deep-breathing exercises several times a day. The deep breathing that accompanies vigorous work and play is far more beneficial than breathing exercises.

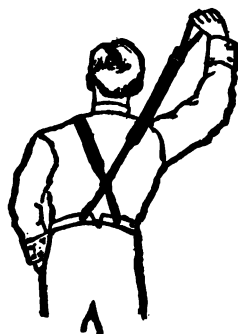


FIG. 112. — Suspenders should have a pulley or lever at the back, that the strap on one side may loosen when one shoulder is raised.

with spirits. Large numbers of people are so negligent and careless about their bodies, that cold feet, or other evidence of weak circulation, if not

PRACTICAL QUESTIONS. — 1. State how in the case of a person of ungraceful figure, a gradual remolding of cartilages (which ones?), the strengthening of the muscles (which ones?), and the practice of deep breathing may each contribute toward acquiring a correct and perfect figure. 2. Should a hat be well ventilated? (A punch for making the holes costs a dime.) Should a hat be stiff or soft? 3. Name habits that impair the power of the lungs. 4. How could you convince a person that a bedroom should be open while and after it is swept? That it should be ventilated at night? 5. Which is the more injurious to others, tobacco chewing which causes the ground to be unclean, or smoking which renders the air impure? 6. Why do those who stand straight up to hoe not get tired half so quickly as those who bend or "hump" over? (Chap. VI.) 7. Why do students who sit in rocking chairs, or from other causes, lean the head forward when they study, often find that they recover from drowsiness if they sit erect, or sit in a straight chair? 8. How are high collars a fruitful source of bad colds? 9. If the draft up the chimney of the fireplace, when the fire is burning, takes up a volume of air sufficient for many people, why is it unnecessary to open a window? 10. Why does cold, impure air make a person colder than cold, pure air? (p. 14.)

BACTERIA: INFECTIOUS DISEASES

Independent Plants and Dependent Plants: Green and Colorless Plants. — *Most plants get their food directly from the mineral kingdom*—from the solid minerals in the earth and from the gaseous minerals in the air. The plants that do this always live in the light and contain green substance. This green substance is most abundant in their leaves. By the aid of the sunlight, the plant takes carbon dioxide from the air and gives back oxygen to the air (see Fig. 118). There are *some plants which cannot use mineral foods, but must live on dead plants* and use the material which those plants assimilate from minerals. Such plants are never green. Examples of them are mushrooms, toadstools, devil's snuffbox, fungus, and tiny plants called *mold*, which forms on bread, leather, etc., in damp weather.

Germ, or Microbes.— Scientists were in doubt for a while as to whether the microscopic one-celled germ called microbes, or *bacteria*, were plants like mold or animals like the ameba. It is now definitely known that *germs, or bacteria, are vegetables*. They are not green, hence they must depend upon plants or animals for food. There is another class of one-celled plants, somewhat larger than bacteria, which are called *yeast plants*. Study the table on page 124 and find how bacteria, yeast, and mold differ in size, food, reproduction, products yielded, and conditions which favor their growth.

The Work of Bacteria.— Dead plants and animals contain materials which are of the greatest value as food for living plants and animals. As other plants and animals die, this material, unless it decayed, would accumulate until all the plant food would be stored up, and all the space needed by young plants and animals would be occupied by logs and leaves and carcasses, and the earth would be no longer habitable. There is no decay without the action of bacteria, yeast, or mold. *Their work is to destroy unsound or dead animal and vegetable matter* by living upon it as food. Thus it is returned to the soil and air, ready to be used as plant food again.

Nature of Germ Diseases.— A plant, as an oak or a pear tree, may become affected by a disease called the blight, and such disease is usually regarded as a necessary evil, or imperfection in creation. Looked at with a broader knowledge, such disease is a sign of growth as well as of decay, and is a blessing and not a curse. The microscope shows that trees affected with the blight are the seat of the growth of millions of these one-celled plants called bacteria. So where there is death and disease, there life is also flourishing. *The blight did not attack the hardy,*

TABLE. — MOLDS, YEAST, AND BACTERIA COMPARED

NAME WITH EXAMPLES	AVERAGE SIZE	FOOD	REPRODUCTION	CONDITIONS OF GROWTH	PROCESS OF GROWTH AND PRODUCTS
Mold (mildew, ringworm).	$\frac{1}{10}$ inch in di- ameter.	Wood, starch, sugar, pro- teid.	By dustlike spores.	<i>Aided by acid, moisture, heat.</i> <i>Prevented by dryness, sun- shine, cold, cleanliness.</i>	Molding (decayed wood, etc.).
Yeast (bakers' yeast).	$\frac{1}{100}$ inch in diameter.	Sugar and starch.	By budding.	<i>Aided by warmth (80° F.), moisture.</i> <i>Prevented by cold.</i>	Fermentation (car- bon dioxide, alcohol).
Bacteria (also called microbes or germs).	$\frac{1}{20000}$ inch in diameter.	Proteid.	By dividing: one into two, two into four, etc.	<i>Aided by alkalis, heat, moisture.</i> <i>Prevented by acid, dryness, cold, boiling, cleanliness.</i>	Putrefaction (tox- ins, ptomaines).

sound pear trees, but those of rapid, sappy growth, whose tissues had already become unsound or dead, from the effect of frost or overcultivation.

Bacteria in the Human Body. — Bacteria, or germs, do not always wait for the dead or dying material to be excreted, or separated from the animal or plant, before attacking and destroying it. If more food is eaten than can be digested, and it remains longer than five hours in the stomach, starchy food may ferment from the growth of yeast plants, giving rise to carbon dioxid gas; albuminous food may be decomposed by bacteria; or a growth of mold may form on the lining of the organs, extending up to the mouth and forming a coat upon the tongue. If the lungs are never fully expanded, but by stooping over at work or by tight clothing a



FIG. 114. — ROD-SHAPED BACTERIA (BACILLI) OF LOCKJAW. Some of the bacteria have an oval spore near one end. (Peabody.)

part of a lung is compressed and the blood supply interfered with, or if foul air is constantly breathed, cells and tissue in the lungs may become unsound and the bacteria may use them for food. The bacillus tuberculosis is a form of bacteria that sometimes finds a fertile soil in the lungs. In thousands of cases of consumption, bacilli destroy an injured part of a lung and it heals over. This is very likely to happen if the person returns to natural ways, lives out of doors, and allows the cells to purify the body. Dissections made in medical schools show

scars on the lungs in thousands of cases. These scars were left by consumption, with which the persons had been affected without knowing it and from which they had entirely recovered, dying afterward from another disease.

Bacteria destroy the Weak and leave Room for the Sound and Strong.—But in many cases the individuals have lived wrong physically for so long, and their lungs have become so weak, that they are gradually destroyed by the bacilli. This is sad to the individual and his friends and loved ones, but *it is best for the race, for it prevents gradual degeneration of the race into weaklings.*

Whether the body has been injured through ignorance or self-sacrifice, through dissipation or selfish ambition for money or fame, through foolish attempts at beauty or through devotion to learning, or through unselfish love and work for others, the result is the same; nature knows no difference. However noble the character or wise the mind on other subjects than health, when the body has been neglected or foolishly treated, and a vital organ has sunk in health below the standard necessary for a human being, condemnation comes.

Effects of Bacteria.—They produce decay in unsound tissue. They destroy the albumin in which they grow, producing foul-smelling gases and a number of poisons called *toxins* if formed in the living body, and called *ptomaines* (to'manes) if formed after death. Ptomaines in spoiled meat cause most of the symptoms produced by eating it. A special kind of ptomaine sometimes forms in milk and ice cream that has been kept for a long while. For this reason ice cream which has been melted and frozen a second time is dangerous.

Toxins, circulating among the tissues of a living body,

may produce weakness and disease. *Typhoid fever* is usually contracted through the use of water from an impure source. There have been cases of a spring or well becoming infected with typhoid germs, and giving typhoid fever to the unhealthy members of every family that used water from it. The same effect sometimes results from the use of milk carried in cans which have been washed

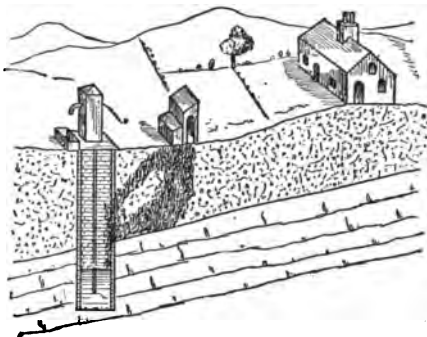


FIG. 115. — Well polluted with sewage.

in water from an infected well or stream (Fig. 115). It requires many bacteria to produce infection; to cause some diseases, several millions are necessary.

It has never been proved that germs will cause harm or disease to a perfectly healthy body. *Some germs change their nature or the nature of the toxins they form, according to the material upon which they live* (Fig. 116). Many germs seem to be harmless when living in certain conditions, but, if they find a diseased condition, they seem to change their nature and begin the formation of poisonous toxins. This is known to be true of the colon bacillus, and is possibly true of typhoid fever germs. Thus in many cases it is an impure body which supplies the germs with poisonous food, and they only return poison to the body.

How Bacteria are destroyed within the Body. — First, the *white blood cells* have it for their chief function to seek out bacteria and to devour and destroy them. This explains why many germs are necessary to transmit a disease.

Second, *the lymph, the watery portion of the blood*, and even mucus are able to destroy germs of disease. The



FIG. 116. — *a*, germ destroyed by white blood cell; *b*, cell destroyed by germs, the germs multiplying and using the cell as food.

serum of the blood often contains a counter-poison, called an antitoxin, which poisons the germs and stops their action. The glands in the neck (thyroid) and over the kidneys (supra'renal capsules) and white blood cells produce antitoxins.

How White Corpuscles do their Work. — When a blood vessel is looked at under a microscope (see Exp., p. 90) the red cells are seen floating along the center in a steady current (see Fig. 117). Here and there along the wall of the vessel, transparent white corpuscles will be observed. These curious cells go loitering along the wall, stopping now and again. *A white cell is merely a little drop of living jelly with a nucleus*, but without a cell wall. After a while the cell comes upon a little speck, a germ, a particle of medicine, or some other particle foreign to the body. The side of the white cell which happens to be next to

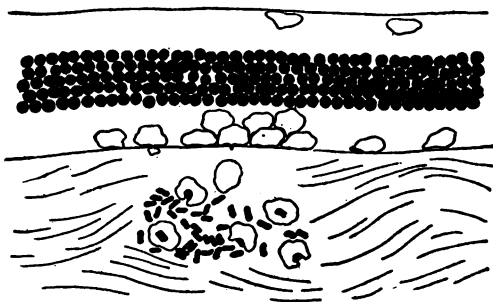


FIG. 117. — BLOOD VESSEL with red cells along the center and white blood cells leaving vessel to attack germs in surrounding tissue.

the speck flows out on all sides of the speck as if it were stretching out lips. *Thus the germ or speck is surrounded*

and carried off inside of the cell. Soon the speck is dissolved or digested, and disappears. This is occurring in the body all the time; these little guardians are ever protecting us.

Boils, Pimples, Sores, etc. — Suppose that germs enter at some tiny break in the skin. The body is well prepared to defend itself against them. *The white cells bore their way through the walls of the blood vessels (p. 133) and come crowding around the infected spot.* Soon a white spot appears, and we say the boil has come to a head. Then it breaks or is lanced, and a mass of white matter exudes. The microscope shows it to be composed of white cells that have died while battling against the germs and destroying them. Some people regard pus as impure matter taken out of the blood in order to purify it. This is a mistake. It is the remains of white cells that have lost their lives in defending the body. The reason that there is not a boil every time a break in the skin allows germs to enter, is that usually the white cells are so vigorous that the germs are destroyed by the first few corpuscles that reach the spot.

Inflammation. — If the capillaries of any part are weak, they may be strained when they are congested with blood driven to them by exposing the skin to cold. The watery portion of the blood exudes through the injured vessels; the white blood cells collect to repair the injury and the part swells. When germs or poisons enter any part of the body, inflammation may occur. *The place swells up, not only because the white corpuscles collect there, but because the serum of the blood is poured out into the tissue to dilute the poison and by its antitoxins destroy the germs.*

Need for keeping the Blood Pure. — *If blood contains an excessive amount of poison, the white cells are weakened*

and cannot defend the body. Once some germs were injected into the body of a bird; they did no harm at all. Later, a small amount of nicotine was injected in the bird's blood. The germs were again introduced and soon killed the bird. Alcohol, opium, tea, coffee, strychnine, arsenic, calomel, and the poisons that pass into the blood by half-digested food, likewise lower the resisting power of the body. A coated tongue means a low vital resistance; the moldy growth on the tongue is there because the saliva is no longer able to destroy germs, etc. The body is in a run-down condition, or the food tube has been shamefully overloaded. The saliva of a healthy person will destroy germs and keep the tongue clean. When the army of white corpuscles is strong, one does not take contagious diseases. When the army is weak a disease is readily taken.

Germs alone cannot cause disease. A thief wished to obtain food in a man's house. Three of his friends bound the watchman, another picked the lock, and the thief himself went in and feasted on the food in an overstocked pantry. Did he alone rob the house? If gluttony, alcohol, or tobacco paralyze those watchmen, the white blood cells, if the mucous membrane or the skin is weak, and the germs enter and feed upon tissue already unsound, it cannot be said that the germs alone caused the disease.

Diseases caused by Animalcules. — Germs are one-celled vegetables. Several kinds of one-celled animals, like the ameba, also cause disease. The ameba itself causes a severe kind of dysentery if it enters the intestine of man. *Yellow fever* is believed to be caused by an animalcule that lives as a parasite in the bodies of a certain kind of mosquito. The plasmodium, another kind of parasite which lives in certain species of mosquito, is believed to

transmit *malarial fever*. This mosquito has five appendages on its head and alights with its body held out instead of parallel to the supporting surface. Malarial fever returns at somewhat regular intervals, as each generation of plasmodia mature and multiply, setting free many new ones in the blood. Quinine taken just before the fever is due causes the animalcules to disappear from the blood. Some scientists believe that it destroys them, others believe that it only causes them to disappear into the bones or the spleen or some tissue that the quinine does not reach. Even if the quinine cannot cure malaria, it at least postpones the attack and gives the sufferer, who is usually able to be out of bed, a few days of grace in which to strengthen his body by hygienic living, so that his white blood cells and his enriched blood can destroy the plasmodia and stop the disease. Whatever is needed, whether it be purer water, simpler food, more temperate eating, cold baths, or avoidance of stimulants, will be promptly adopted by people with intelligence and prudence enough to help themselves. *Cold baths send the blood bounding to the most secluded parts of the tissues, cause the blood cells to multiply rapidly, and prevent malaria and aid greatly in curing it.* Of two sisters in a home, one may have malarial fever, the other may not. The reason is that one has some unhealthful habit, such as worrying, fretting, overeating, or idling, while the other has good habits, such as cheerfulness, temperate eating, industry, her blood is richer and every germ transmitted to her blood by the bite of the mosquito is promptly destroyed. Those who rely entirely on drugs to recover health may have to take many doses in vain; they may become dyspeptic and constipated from calomel, and partially deaf and nervous wrecks from quinine.

Cleanliness. — Germs are everywhere ; but they are able to harm only weakened bodies. Since it is important that the white blood cells be not outnumbered and overcome by germs, cleanliness is of the greatest importance. Consumptives should use paper for spittoons, that it may be burned before it dries and prevent the germs from being blown about in the air. The excrement of typhoid fever patients should be disinfected with chemicals that destroy germs. Bedding and clothing used by persons while ill with smallpox should be destroyed, as those germs preserve their vitality for years. Children with scarlet fever, measles, or other infectious diseases, do a great wrong if they come to school. A cistern for rain water should be cleaned out once a year, in the autumn after the leaves have fallen.

FERMENTATION

The Nature of Fermented Drinks. — The fact that alcoholic drinks, like wine, beer, and cider, are made from fruit and grain suggests the false idea that they are also healthful and nourishing. Knowledge of the changes which fruit must undergo to produce these liquors corrects this false idea. The skin of fruit protects it from decay even though the yeast plant is on the outside of this skin.

Experiment 29. With a large microscope look at a drop of water in which you have washed grapes or apples. You may be able to see some little round cells, which are called "yeast plants" because others like them compose bakers' yeast. It is these yeast plants that cause sweet fruit juices to change very soon after they are pressed out. See Fig. 74. (Photomicrographs.)

Experiment 30. If you put a tablespoonful of sugar into the water in which you have washed some apples or grapes,

and set the glass in a warm place for a day or two, you will probably see tiny bubbles rising in it. This shows that the sugar is changing, or *fermenting*.

If you can now look at the yeast plants in the liquid with a microscope, you will find them growing and multiplying. To support their life and growth they need oxygen, and this they are able to get from the sugar which you put into the water. In getting it they cause the sugar to break up into two entirely different substances, — carbon dioxid, a gas which you see as bubbles, and alcohol, which you do not see. What is the difference between sweet fruit juice when within the fruit and cider, or wine, made by pressing out the juice and allowing it to ferment?

Beer making causes two changes in the nature of the food originally in the grain. By keeping the grain moist and warm until it sprouts, its starch is changed to sugar, which is soaked out with water after the sprouts are killed by heat. Into the sweet liquid thus obtained yeast is put, which soon changes the sugar in the liquid to carbon dioxid and alcohol. This liquid, now called beer, contains the same poison as wine and cider.

Why there is Danger in Wine, Beer, and Cider. — A poison may injure some of the cells without immediately causing the death of the whole body. The generally accepted definition of a poison is, "A substance whose nature it is when absorbed into the blood to injure health and destroy life." The amount of injury depends, among other things, upon the quantity of poison taken and the ability of the cells to resist it. Cells that are vigorous, well nourished, and healthy can resist poisons better than those in opposite conditions. *The most dangerous effect of alcohol upon the body as a whole is that it has the power to create an almost irresistible appetite for more.*

Distilled Drinks. — If a vessel of water and a vessel containing alcohol are placed side by side on a stove, the alcohol evaporates much more rapidly than the water. Taking advantage of this fact, fermented liquids, which contain much water, are changed to distilled drinks such as whisky and brandy. After much of the water is evaporated or distilled away the distilled drink contains forty, fifty, or even sixty per cent of alcohol. Fermented drinks contain from five to twenty per cent.

EXERCISES IN WRITING. — The Hand. The Foot. Right Habits of Breathing. Why Some Boys learn to Smoke Cigarettes. The Cigarette Habit. Improvement in Dress. Housekeeping. Why a Certain Friend of mine has so Many Colds. A Story of Camp Life and how it affected Health. It is easier to keep Well than to get Well. How to Ventilate Assembly Rooms. Why I believe in Ventilation. A Friend who has a Horror of Drafts. How to have Good Lungs. A Spree. A Young Drinker who squandered his Inheritance. Shall I Smoke?

ALCOHOLIC REMEDIES AND CORRUPT PERIODICALS. — We desire to call attention to the dangerous character of the hundred and one largely advertised nostrums which are offered the public as "Bitters," "Renovators," "Anti-Chill" mixtures, "Catarrh Cures," etc., these abominable concoctions being harmful in direct proportion to their alcoholic or narcotic strength.

A report recently made gave the alcoholic average of all the popular and most widely advertised patent medicines as from ten to forty-five per cent alcohol, and if this does not open the eyes of physicians to the gigantic nature of this evil, nothing will. The dram drinker who goes to the saloon soon makes a wreck of himself. People who value sobriety and steady nerves steer clear of the known bar frequenter; the railroads keep an eye upon engineers and trainmen, and those who spend their pay at saloons soon get a chance to change their vocations. But the man who buys at the drug store some one of these alcoholic alleged "tonics" often finds himself compelled to continue its use. His nerves get shaky, his eyes are not as true as they were, and quite likely he buys still more of the same noxious stuff, believing that his stomach and nerves need "fixing." As long as he takes his tippie three times a day (or oftener), he feels pretty well—he is working under alcoholic

stimulation. Now let him attempt to stop and he will find he is "gone to pieces"; but none counts *him* a "drunkard"; he, himself, would scout the idea.

The victims of this alcoholic nostrum habit are to be counted by hundreds of thousands; mothers and thoroughly good women who would die sooner than "drink" take these wretched mixtures and find a transient strength therein, which leads them to "buy another bottle," with the result that sooner or later they are *compelled* to continue the habit or collapse. If the periodicals which advertise these drunkard-making medicines realize the damage they are doing, they must be edited and controlled by peculiar men. The religious press especially offends decency and good morals by exploiting a host of these and worse preparations. And, to tell the truth, the medical press is not free from taint. The temptation is perhaps great to accept a profitable advertising contract; but when one puts against the dollars gained the ruined lives which must follow the use of the poisons advertised, the temptation vanishes.

The greater proportion of the public after all does not live near the saloon, and it is to these country dwellers that the rum-tonic men look chiefly for their trade. — *The Alkaloidal Clinic*.

REVIEW QUESTIONS. — **Chapter IV.** 1. State facts which show the varied uses of the muscles. 2. What are the two classes of muscles? 3. Describe appearance and structure of voluntary muscles. What are the bundles, fibers, and fibrils? 4. What is the structure, position, and use of involuntary muscles? 5. What is (1) the structure; (2) the use, of tendons? 6. Describe the action of the gullet; sphincter muscles; facial muscles; calf muscles; tailor's muscle; flexors; extensors. 7. When is the best time for developing the muscles? 8. Describe the harmonious action of all the muscles when a boy throws a stone. How is this harmony made possible? 9. Describe the connection of a nerve with a muscle, and the effect of one nerve impulse. 10. What is the source of muscular energy? 11. How is a muscle kept contracted? 12. What is muscular tone? Give evidences of its existence. 13. What causes fatigue? 14. Why does rest relieve it? 15. How is general fatigue caused by the action of a few muscles?

1. How does physical exercise aid the appetite; the circulation? 2. What advantage have useful labor and games over gymnastics? *Vice versa*? 3. What kind of muscles belong to us by inheritance? Show why those who try to be healthy without exercise are attempting an impossibility. 4. State the amount of sickness in the United States and the chief causes of it. 5. Show that many persons do

not use common sense with reference to health. 6. Show that it is never really one's duty to neglect the health. 7. How would instinct guide in using the muscles? How is this instinct usually disregarded? 8. Discuss exercise in different climates. 9. Discuss the relative respect due to physical and mental labor. 10. Describe a better way to attain complete living than by taking set exercises.

REVIEW QUESTIONS. — Chapter V. *The Circulation.* 1. Does an *ameba* need a circulation? Why does a man need a circulation? 2. State size, shape, and position of the heart. 3. Why must the heart be double? State the work of each pump; the five parts of each pump. 4. Trace the blood in one complete circuit. 5. Explain the structure and use of each of the three coats in a blood vessel. 6. Why must the blood vessels be smooth; elastic; vary in size from time to time? 7. Describe how a pulse wave travels. 8. How may the special supply of blood furnished to any organ be increased; decreased? How may more fresh blood be sent to all the organs at the same time? 9. Describe the capillaries as to structure, use, and blood flow. 10. Describe the walls of the veins. 11. Describe an experiment to show the effect of gravity on the blood flow; to show the working of the valves in the veins. 12. What usually causes fainting? What should be done to aid recovery? 13. Give a clear account of the action of the valves in making the blood flow faster through an actively contracting muscle. 14. Why does faster blood flow from muscular exercise make the heart beat faster? 15. What is the effect upon the blood flow when the chest expands; contracts? 16. How do exercise and physical labor strengthen the heart? 17. Why can we not blush or change the beating of the heart at will? 18. What nerves increase the heart beat; what decrease it? 19. How does the heart obtain nourishment from the blood?

1. The microscope shows the blood to possess what parts? 2. What is each part for? 3. What is meant by the pulmonary circulation; the systemic circulation; arterial blood; venous blood? 4. Describe the three purifications of the blood. 5. Describe the process called coagulation. Of what use is it? 6. Compare veins and arteries in the following points: walls; closing when cut; position; color; flow of blood; where they begin and empty.

1. Of what does the lymphatic system consist? 2. What is the appearance of lymph? Where have you seen it? 3. Why are lymph spaces necessary? 4. What is the function of the lymphatics? 5. How does (1) carbon dioxide, (2) other waste materials, (3) unused food, go from the lymph spaces into the blood? 6. Which circulatory system has neither beginning nor ending; both beginning and end-

ing? 7. Into how many vessels do the lymphatics finally unite? Give their names. Into what do they empty? 8. What is dropsy? 9. What and where are the lacteals? 10. State several ways in which the lymph is made to flow. 11. What is the function of the lymph glands? 12. What is the origin of the white corpuscles? 13. What is the function of the spleen? 14. Show that the blood is more necessary to life than are the nerves. 15. What is the greatest benefit from muscular exercise? 16. Show the fallacy of a "blood purifier." 17. Describe the direct and indirect effects upon the skin of an improved circulation; upon fat; upon the muscles; skeleton; brain; lungs; heart; stomach. 18. Discuss thin blood (anemia); how it comes; how avoided. 19. Where do red blood cells begin?

REVIEW QUESTIONS. — Chapter VI. 1. How are the lungs constructed so as to increase the surface for absorbing oxygen? 2. What are the three stages in respiration? 3. What cavity is behind the mouth and nasal passages? 4. What tubes open into the pharynx from below? Which one has a lid? 5. What is the structure of the trachea? 6. Describe the branching of the trachea? 7. What is a bronchial tube; lobule; air cell? 8. What are cilia? 9. Describe the lungs; the pleura. 10. Name the chief breathing muscles. 11. Describe the position of the diaphragm. 12. How do the chest walls and floor move during inspiration? Why does the air go in? Why do the lungs expand with the chest? 13. What causes the diaphragm to ascend during expiration? Why cannot the diaphragm press upward without being lifted by the organs below? 14. When and how does expiration occur without muscular effort? 15. Discuss chest breathing, abdominal breathing, and full breathing. Which is the natural way? Why should no discussion ever have arisen regarding it? 16. What are the disadvantages of the other methods? 17. Why is a person with flabby abdominal walls likely to have a stagnant liver? (p. 87.)

1. Describe three experiments to show the changes which the air undergoes in the lungs. 2. What is the origin of "crowd poison"? 3. What is said of bad ventilation in assembly rooms? 4. Discuss dust; sweeping; dusting. 5. Which methods of heating allow best ventilation? 6. Why should a stove always be near a window? 7. State the reasons for breathing through the nose. 8. Describe how the lungs and air passages are affected in the several diseases mentioned. 9. Discuss the prevention of colds and lung troubles.

CHAPTER VII

FOOD AND DIGESTION

The Uses of Food ; Heat. — The body keeps at a temperature of 98.6° in the coldest weather. The temperature of the Eskimo boy living in the frigid zone is the same as the temperature of the negro living in the torrid zone. The interior of our bodies is as warm on the coldest winter day as in summer. *The source of the heat is the burning of the food which we eat by the oxygen which we breathe.*

Work. — A horse does work when he draws a wagon. An engine does work when it moves a train of cars, or even when it moves itself. Our bodies are capable of moving and of exerting force. To exert force or to do work uses energy. What is the source of this energy? *Its source is likewise the burning of the food by the oxygen.*

Growth. — The body of a young person grows, or is built up, cell by cell. The cells obtain not only the material, but the strength, or energy, necessary for building the body, from the food and oxygen. Hence *the uniting of food and oxygen in the body is a source of heat, work, and growth.*

The Steps in Nutrition. — After being eaten the food must first be made soluble that it may be carried by the blood. This change is called *digestion*. When the blood and lymph bring the food in reach of the cells, the cells absorb it and change it into material like themselves.

This process is called *assimilation* or, in simple English, "a making like." The activity of the cells by which the burning takes place and the compound substance is broken down into carbon dioxid, water, and urea is called *oxidation*. The ridding of the body of the products of oxidation is called *excretion*. Food is sometimes called *nourishment*. The combined action of all the organs concerned in nourishing the body is a process called *nutrition*.

Energy cannot be destroyed, although one form of energy can be changed to another kind. By rubbing a coin on the table, muscular energy produces motion, which in turn produces heat, for the coin will become very hot.

The Bodily Furnace and the Storing of the Fuel. — More or less motion of the body or some of its parts is constantly taking place; heat is constantly escaping from the body; the tissues are constantly being repaired. The energy to replace that which is lost comes from the oxidation of the food. Not all of the food, when absorbed from the food tube, enters the active cells, but some of it is deposited in storage cells called *fat cells*. This is like coal banked up in the furnace, which the fire has not yet reached. In our bodies *the furnace is in the cells*; wherever there is living tissue, the contents of the cells are being burned to enable the tissue to live and to work.

Different Forms of Burning. — To a chemist anything is burned when it unites with oxygen. If the burning takes place at great heat and very rapidly, it is called *combustion*. There is no combustion in the body. *The oxidation in the body takes place not only at a low temperature, but in the presence of moisture. The rusting of iron and the rotting of a tree* are examples of oxidation that is aided by moisture. Yet the same amount of heat is set free by the slow rotting of a tree as would have been set free by burning it in a

furnace. In the first case the heat set free is carried off nearly as fast as it appears. In the second case the heat is given off in a much shorter time. Rotting and rusting are even slower than the oxidations that take place in our bodies.

Amount of Energy set free in the Body. — One of the chief kinds of energy set free in the body is *heat*. The amount about equals that produced by the *continuous burning of two ordinary candles*. The body is a powerful machine, and is capable of expending a great deal of energy in the form of *work*. The amount of work that the body can do in a day has been carefully estimated. It is equal to *lifting its own weight a foot high every second* for twenty-four hours. One seventh of this work is done by the heart. About an equal amount of work is performed in the movements of breathing. The remainder of the work is done by the other muscles of the trunk and limbs, and by the involuntary muscles of the food tube. The energy expended in the process, *growth*, has not yet been accurately estimated.

The Body as a Machine. — *A working steam engine is warm because of the fire in the furnace; so our bodies are warm because of the oxidation in the cells.* The heat is distributed through the body by the blood.

The body has many parts which correspond to the parts of machines. There are the *bones which act as levers*, the *hinge joints*, the *pivot joints* which resemble the action of a *wheel*. The blood vessels resemble *hollow pipes*. There are *hollow tubes which give strength with lightness*, as do the hollow tubes on a bicycle frame. Name some of the hollow bones.

How Energy is stored in Food. — *The energy of the food comes from the sun and it is stored up by the sunlight.*

No plant grows in the dark except the simple plants like mushrooms, which get their food by living upon decaying plants. All animals live upon plants. Those animals which live upon other animals are, of course, indirectly feeding upon plants. *The plants, aided by the sunlight, store up starch, sugar, oil, and albumin.*

The leaves of plants, by separating the oxygen from carbon in carbon dioxid, and giving off the oxygen through their pores, prepare the air for us to breathe (see Fig. 118).

The force to do this comes from the sun; only green leaves can accomplish it, and leaves must grow in the light in order to be green.

It is impossible for an animal to gather up energy from the sunlight and store it away; fortunately, it is also impossible for the plants to use up the energy which they gather. They use a little of this

energy in growing, but they cannot use it in moving, or in keeping themselves as warm as animals. Birds fly; some seeds of plants have wings, but they cannot fly unless borne by the energy of the wind. *Plants store up energy; animals expend it.*

The Four Kinds of Food Stuffs.—The *kinds of food which we eat seem to be numberless, but they contain only four kinds of food stuffs*,—starches, fats, proteids, and minerals. Many foods contain all four classes of food stuffs. Milk contains sugar (a changed form of starch); cream (a fat), casein (a proteid), and water. Oatmeal contains starch, oil, gluten, and water.

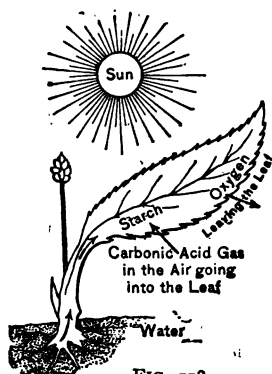


FIG. 118.

BLACKBOARD DIAGRAM.

The plant taking in carbonic acid gas, called also carbon dioxid, produced by burning or animal life. Aided by the sun's rays, the leaf builds the carbon into starch, wood, etc., and gives back the oxygen to the air.

TABLE OF FOOD STUFFS

1. Proteids, the building foods (also of value as fuel).
 2. Starches (and sugars)
 3. Fats (and oils)
 4. Minerals (water, salt).
- } Energy and heat producing foods.
- Important aids in using other foods.

Starch and the sugars are closely related; indeed, starch readily changes into sugar. They contain much carbon and are called carbohydrates. Starch is especially abundant in grains, seeds, and fleshy roots (Fig. 119). Sugar in ripe fruit

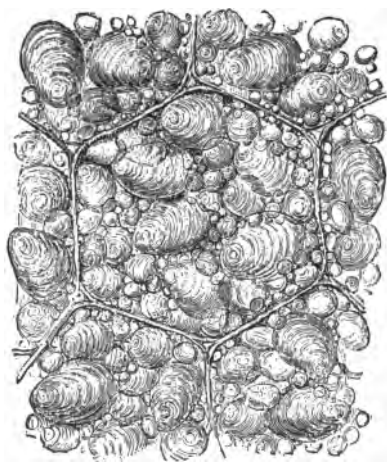


FIG. 119. — A TINY BIT OF POTATO, highly magnified, showing cells filled with grains of starch. See Fig. 140.

and in honey is called *fruit sugar*. *Milk sugar* is found in sweet milk. Grape sugar is found in grapes and honey; the small grains seen in raisins consist of *grape sugar*; it can also be prepared artificially from starch. *Cane sugar* is found in cane and in the sugar beet.

Experiments. — 31. A few cents' worth of tincture of iodine from the drug store will enable the teacher to show the tests for starch and proteid. A portion of the iodine, diluted with water to a light brown color, causes the *starch* in potato, grain, etc., to *turn blue*. Do fleshy leaves, stems, and wood contain starch. 32. Strong iodine will cause the *proteid* of grain, potato, etc., to *turn brown*.

Fats include the fats and oils found in milk, flesh, and plants. A fat, such as tallow, is solid at the ordinary

temperature; while an oil, such as olive oil, is liquid at the same temperature. Tallow was oil while it was in the warm body of the ox. Fats and oils, although so different in taste from starch and sugar, are composed of the same three chemical elements, but they are combined in different proportions.

Proteids are the only foods that contain the tissue-building nitrogen. We do not often see a pure proteid food, for this food stuff is not so readily separated from foods containing it as are starch, sugar, and fat. *Albumen*, or white of an egg, is proteid mixed with four times its weight of water. Pure proteid, or *albumin*, readily coagulates when heated, and in this way it is easily recognized by chemists. These are the names of proteids, or albumins, found in several common foods: *casein*, the curd or cheesy part of milk; *myosin* of lean meat; *fibrin* in blood; *legumen* in beans and peas; *gluten*, or the sticky part of wet flour; *albumen*, or the white of an egg; *gelatin* in bones. Remember that proteid is valuable to the body as fuel as well as a tissue builder. We could burn beans and peas as well as the strictly fuel foods, starch and fat, in an engine, and get heat to move the engine.

Minerals. — The body is about two thirds water. The cells must do all their work under water. They cannot live when dried. Water enables the blood to flow; and the blood is not only the feeder, but also the washer and cleanser of the tissues. Some persons get out of the habit of drinking plenty of water, and their health suffers thereby. If such a person will drink two tumblers of water upon rising, three an hour or two before dinner, the same before supper, and two upon retiring, or ten tumblers (amounting to two quarts) each day, he will probably find himself restored to perfect health. Watery

foods and fluids taken at meals will reduce the amount of water drunk at other times, but it is best to observe moderation in taking fluids at meals. Common salt is used by all races, but it is used least by the Eskimos and others that live chiefly upon meat. It is needed most by lower animals and men that live chiefly upon plants for food.

Wastes. — It is clear that the body must return daily to the outside world about as great a weight of material as it receives from it. The wastes of the body result from oxidation in the tissues; they consist of *carbon dioxid gas*, a white solid called *urea*, and *water*. The first is given off by the lungs, the second by the kidneys, and the last by both lungs and kidneys. These wastes are very simple compounds compared to sugar, fats, and proteids, which are very complex substances, built up by the green matter in plants, aided by the sunlight.¹ The animal body has not the constructive power of the plant; it can only tear down what the plant has built up. The three physiological wastes mentioned are the result of vital processes. *Another kind of waste* consists of refuse materials, as wood fiber in green vegetables, rejected by the alimentary canal.

Sources of Food. — All parts of a **plant** may furnish food: the *seed*, as the various grains, nuts, and fruits; *leaves*, as lettuce, cabbage, dandelion; *roots* and *tubers*, as potatoes (Fig. 119), beets, turnips, tapioca (root of cassava); *stem*, as sago (pith of sago palm); *saps*, as sugars (of cane, beets, and maple tree); honey, and oils (from peanuts, cotton seed, olives, pecans, and other nuts). Food from an **animal** source may consist of: *flesh*, as beef, mutton, veal; *milk*, with its products, as butter and cheese; *eggs* of birds. *Salt*, one of the two chief **mineral** foods, is obtained from

¹ The chemical formula for water is H_2O , for carbon dioxid, CO_2 ; but the chemical formula for protoplasm is *about* $C_{60}H_{100}N_{16}O_{20}$.

mines and wells; *water* is obtained from springs, wells, lakes, rivers. It is of the very highest importance that water should be pure and uncontaminated with vegetable or animal matter.

The Daily Ration. — *A quarter of a pound (4 oz.) of proteid foods and one pound (16 oz.) of fuel foods* are needed to replace the daily waste of the body. The twenty ounces of food to make the ration for one day are reckoned on the basis of dry or water-free foods. It is seen that the two kinds of foods are needed in the *proportion of one to four* (4 oz. to 16 oz.).

Limits to Scientific Regulation of Diet. — It is impossible as well as undesirable to select food so as to regulate the diet according to exact calculations of their composition. If possible to do so, it would cost an immense amount of labor and care. *Appetite is a perfect guide for those who lead an active life and eat simple food.* Highly seasoned food and complex mixtures deprave the appetite; it then leads astray, instead of guiding safely. Of course the appetite cannot guide one to eat the right kind and quantity of food at a table where the food lacks any of the four necessary food stuffs, or where innutritious or indigestible food is provided.

One extreme is where housekeepers are so ignorant as not to know the difference between a proteid and a fuel food; *the other* is where the diet is regulated without reference to the taste of the consumer. *The moderate course* is for every intelligent person, especially every housekeeper, to study the proper proportions of food, and to calculate, with the aid of tables, the proper combinations of all foods commonly used, thus acquiring a general idea of food values (see pp. 147, 174); then to be guided in selecting the bill of fare by *both the appetite and*

these general ideas. Intelligence in regard to diet enables a housekeeper to provide nourishing food for less money than an ignorant housekeeper often pays for food deficient in nourishing qualities (see Fig. 138, p. 174).

How to select a Balanced Ration. — It is most essential to provide the right amount of proteid (4 oz.); nor should any great excess of this amount be eaten. Sufficient fat (2 oz.) should also be provided. Sugar and starches are found in so many foods that a lack of them in the food is not probable, nor is an excess of them likely to do much harm. A deficiency of starch may be supplied by an excess of fat or sugar. *It is impossible to replace proteid by any other food stuff.* The table on page 147 shows the fraction of an ounce of each element contained in an ounce of each of the foods shown.

To obtain the required daily amount (4 oz.) of proteid from beans alone, 16 oz. of beans must be eaten, for 1 oz. of beans contains only .25 oz. ($\frac{1}{4}$ oz.) of proteid (see Table). This amount, of course, would not be relished. To obtain the amount from lean beef, 20 oz. must be eaten, since 1 oz. of lean beef contains only .20 oz. ($\frac{1}{5}$ oz.) of proteid (see Table). By using half of the above weights of beans and beef, you would take half of the needed proteid in the form of beans, and one half in the form of beef. The 8 oz. of beans would also furnish 4 oz. of starch (see Table). The remainder of the starch needed, as well as the fat, would have to be obtained from other foods.

Suppose you wish to arrange a *ration with three foods*. The simplest, though not the most accurate, way would be (with due consideration to taste and digestion) to select one of the foods because it is rich in proteids, another because it is rich in fat, and the third because it is rich in starch or sugar.

COMPOSITION OF ONE OUNCE OF VARIOUS FOODS IN FRACTIONS
OF AN OUNCE

	PRO- TEIDS	FATS	CARBOHY- DRATES	WATER	MINERAL SALTS	WOODY FIBER
Daily Ration	4 OZ.	2 OZ.	14 OZ.	2 qts.		0
I. NUTS.						
Pecan	.103	.708	.143	.03	.017	
Walnut	.158	.574	.16	.03	.014	
Almonds	.235	.53	.12	.078		
Cocanut	.056	.51		.35		.04
Chestnut	.037	.02	.38	.54	.009	.02
II. FRUITS.			Sugar			
Peach	.007		.045	.85	.007	.04
Apple	.004		.072	.84	.005	.05
Blackberry	.005		.040	.86	.004	.01
Cherry	.005		.10	.84	.007	.02
Grape	.125		.15	.70	.005	
Fig (dried)	.040	.014	.50			
Banana	.050		.20	.75		
III. ANIMAL FOOD.						
Lean beef	.20	.035	.009	.75	.016	
Fat pork	.098	.489		.390	.023	
Smoked ham	.25	.365		.278	.101	
Whitefish	.181	.029		.780	.010	
Poultry	.210	.038		.740	.012	
Oysters	.175	.005		.800	.015	
Cow's milk	.035	.040	.040	.870	.007	
Eggs	.125	.120		.735	.010	
Cheese	.335	.243		.368	.054	
Butter	.003	.910		.060	.021	
IV. PODS OR LEGUMFS.			Starch			
Beans	.25	.020	.52	.125	.035	.060
Peas	.217	.019	.577	.12	.028	.032
Peanuts	.2947	.465	.162	.02	.028	.043
V. GRAINS.						
Wheat flour (white)	.110	.020	.703	.150	.017	.003
Wheat bread	.080	.015	.490	.400	.012	.003
Oatmeal	.126	.056	.630	.150	.030	.016
Maize (corn)	.100	.067	.706	.135	.014	.015
Rice	.050	.008	.832	.100	.005	.040
VI. VEGETABLES.						
Potatoes	.012	.001	.205	.767	.009	.006
Cabbage	.02	.030	.058	.910	.007	.015

Studies based on Table.—What nuts are richest in proteids? What fruits? What animal foods? What legume? What grains? What foods are richest in fats? What are richest in carbohydrates? Which grain has most starch? Which nut? Which fruit has most sugar? A family was living chiefly on corn bread, potatoes, butter, sirup, cakes, and sweetmeats: what food stuffs were deficient in their diet? Another family lived chiefly on fat pork, bread, rice, vegetables, and fruit: which food stuff was deficient? A man tried to live on pecans, bread, fruit, and vegetables: which food stuff was deficient? If he had substituted lean beef for pecans, which food stuff would have been deficient? If he had substituted chestnuts for pecans, what two food stuffs would have been deficient? Why would almonds have balanced the diet, although beef and chestnuts failed in turn? Construct a balanced ration of beef, butter, and wheat bread. Construct one of beans, rice, and fat pork. Construct one of poultry, potatoes, oatmeal, cabbage, almonds, peaches. Select smoked ham, flour, beans, and bananas for one day.

Would it be cheaper to increase the smoked ham and decrease the beans in the above ration, or the reverse? (See table, p. 174.) What weights of each food will be needed if the meals are prepared for five persons instead of one? Why do bread and butter make a ration of about the right proportions? If a farmer has no money to buy meat and bread, can he substitute beans and potatoes and still supply his family with enough of each food stuff? Why is meager food for a nation or a person poor economy? Why is rich food or a large variety of food often a great misfortune?

How the Right Proportions of Fuel Foods and Proteid are reached by Different Nations.—Milk has an excess of

nitrogen, and oatmeal an excess of carbon; oatmeal and milk form a perfect food, and it is not surprising that a whole nation (the Scotch) have lived upon it and thrived. Potatoes are mostly starch and water; the starch in them is more than four times as much as the proteid, and an Irishman who tried to live on potatoes alone would have to eat seven pounds a day to get enough proteid. Every Irish peasant is said to keep a cow and chickens; by eating milk and eggs also he can get along on half the amount of potatoes named above. The Mexicans eat bread made of corn meal, and supply the proteid by using beans as a constant article of diet. The Zulus live on cracked corn by adding milk to it. The Arabs live on barley and camels' milk, rarely eating the camels' flesh. Hundreds of millions of people in Asia (the Hindoos, Chinese, and others) subsist mainly on rice, which contains only six per cent of proteid and no fat; the chief addition they make is butter, or other fat, and beans, which contain vegetable proteid.

Outline of Digestion.—The food is made soluble in the alimentary canal and is absorbed by the blood vessels and lymphatics in its walls. This canal is about thirty feet long (Fig. 125) and consists of—

(1) The **mouth**, where the food remains about a minute, while it is chewed and mixed with the *saliva*; the saliva changes a portion of the *starch* to malt sugar.

(2) The **gullet**, a tube nine inches long, running from mouth to stomach and lying in front of the spinal column.

(3) The **stomach**, a large pouch where the food is stored, and from which it passes in the course of several hours, having become semiliquid, and the *proteids* having been partly digested by the *gastric juice*, an acid secretion from the small glands in the stomach walls.

(4) The **small intestine**, a narrow tube more than twenty feet long, where the *fats* are acted upon for the first time, and where the *starches* and *proteids* are also acted upon, and where, after about ten hours, the digestion of the three classes of foods is completed by *pancreatic juice* from the *pancreas*, and *bile* from the *liver* (Fig. 120).

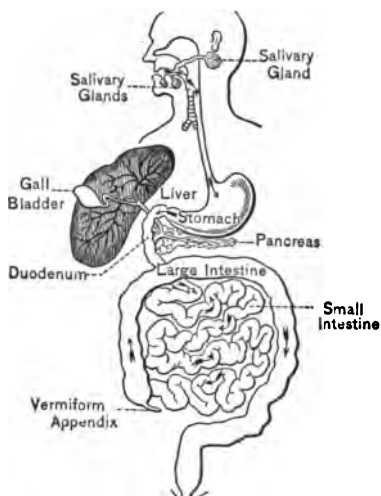


FIG. 120.—FOR BLACKBOARD.

(5) The **large intestine**, about five feet long, where the last remnant of nutriment is *absorbed*, and the *indigestible materials* in the food are gathered together.

The Absorption and Assimilation of Food.—Take a piece of bread in your hand. It belongs to you, but it is not a part of you. Put it into your *mouth* and chew it. Still it is not a part of you. It becomes mixed with the *saliva* and

partly digested. You swallow it and it is now in your *stomach*. Still it is not a part of you. Little by little the *portal vein* absorbs the dissolved bread and carries it to the *liver*, where it is converted into *liver starch* to be stored until it is needed. Still it is not a part of you.

From the liver the dissolved bread finally finds its way into the *general circulation*. But it is not yet a part of you. Having circulated through the blood vessels, it passes from vessel to vessel, smaller and smaller, until it finally reaches the *capillaries*. Still the dissolved bread is not a part of you. It now oozes out through the walls

of the capillaries into the *lymph spaces*, surrounding and permeating every tissue. And yet it can hardly be said to be a part of you.

In every tissue each one of the millions of *living cells* is capable of absorbing to itself a minute quantity of the nutritive juices which touch it. Each of these cells takes something from the lymph, taking only the portion that it needs, leaving the other portions for other tissues. It is only when these minute cells have taken the food from the lymph and *assimilated* it that the digested bread actually becomes a part of you.

Very soon the cells will discard the food in another form as *waste material*. Some of it will be taken up again by the capillary vessels, but the most of it will be taken up by the lymphatics. The lymphatic vessels convey this used material back into the venous blood vessels. It soon finds its way to the *kidneys, lungs, and skin*, to be removed from the body.

Thus the bread which you eat and take into the body is only for a small portion of the time really a living part of your body.

THOUGHT QUESTIONS. — **Tobacco.** 1. Chemical analysis shows that there is enough nicotin in one cigar, if taken into the circulation, to kill two men. Does the experience of tobacco users disprove this? 2. What means have shrewd manufacturers provided so that even children now learn to smoke so gradually as not to awaken the instinctive repugnance to the poison in tobacco? 3. What injury results from chewing tobacco that does not result from smoking? What injury results from smoking that does not result from chewing? Why are weak cigarettes far more injurious than strong cigars? 4. Where has the smoke been that a boy blows out of his nose? 5. Give two reasons why weak tobacco smoke in the lungs does a far greater amount of injury than strong tobacco smoke in the mouth. 6. Why do cigarette smokers usually inhale, or draw, the smoke into the lungs, while cigar smokers do not? 7. Think of *three boys* (without writing their names) whom you know that *do not use tobacco*, and of *three that*

smoke cigarettes habitually. Fill out the following table, placing the boys in two classes, and showing how many of the three tobacco users are fleshy, and how many are thin, etc.; how many of the three abstainers are fleshy, how many of the three are thin, etc.

	Fleshy	Thin	Rosy	Pale or Sallow	Studious	Idle	Obedient	Unruly	Full sized	Stunted
3 tobacco users										
3 abstainers										

Condiments and Narcotics. — Certain substances called condiments, such as vinegar, pepper, and mustard, are sometimes taken for the purpose of exciting a dull appetite. These produce a slightly increased flow of the digestive juices and much mucus. They cannot be classed with any of the four classes of nutritious food. The nerves become dulled to them if used beyond a very moderate amount. When appetite is lacking, it should not be stimulated, lest more food be taken than the cells can assimilate. Part of it will be changed into injurious waste material, poison the tissues, and burden the organs of excretion. Alcohol, opium, and tobacco decrease the feeling of hunger, not by supplying food, but by benumbing the nerves. By dulling the instinct for food, they may cause the body to be insufficiently nourished. If a poor man "breakfasts off a pipe," his body is still as much in need of a breakfast as it would have been if he had not smoked.

The Teeth. — The first and one of the most important steps in digestion is chewing. The teeth cut and grind the food. They fit into deep sockets in the jaws. Get a

tooth from a dentist, and saw or break it into halves. To study the parts of a tooth more carefully, sketch Figure 121 on the blackboard or in your notebook on a large scale. The main body of the tooth consists of bonelike *dentine*, or ivory. Hard, shining *enamel* protects the crown, or visible portion. The part of the tooth beneath the gum is called the neck, and the part in the bony socket is called the root. The enamel ends just beneath the gum, where it is overlapped by *cement* of the root. There is a pulp cavity in every tooth (Fig. 121); it contains *pulp* made up of connective tissue, with nerves and blood vessels which enter at the tip of the root. Since an infant cannot eat solid food, it needs no teeth for the first few months.

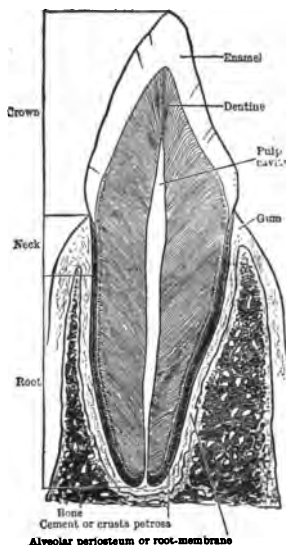


FIG. 121.—CANINE TOOTH CUT LENGTHWISE.

At about the age of six months the first teeth of the *temporary* set appear; this set is completed at about two years of age and consists of twenty teeth (Fig. 122). The

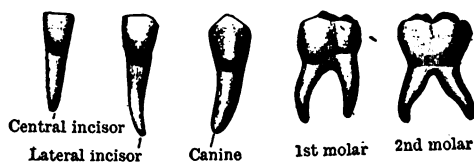


FIG. 122.—THE MILK TEETH in one half of one jaw.

teeth cannot grow as the jaw grows, and soon a larger and *permanent* set starts to growing deeper in the jaw.

The second set begins to push out the first set at about five or six years of age. At the age of twelve or thirteen years all the permanent set have appeared except the four wisdom

teeth, which appear between the ages of twenty and twenty-five. The second set not only replace the twenty of the first set, but to supply the larger jaws twelve molars are added, three at the back in each half jaw, making thirty-two teeth in the second set. The teeth in each quarter of the mouth, named in order from the front, are as follows: two *incisors*, one *canine*, two *bicuspid*s, three *molars* (Fig. 123).

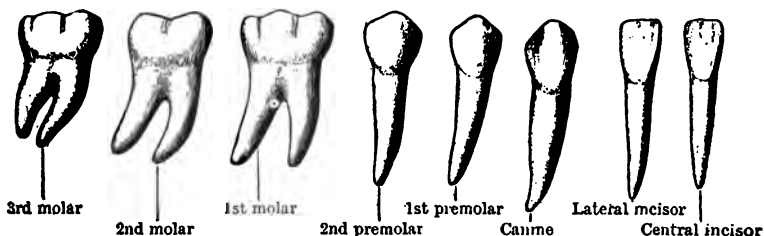


FIG. 123. — THE PERMANENT TEETH in right half of lower jaw. See also Fig. 163.

Observation of the Teeth. — Sit with the back to the light and look into a mirror, with the mouth wide open. Do you see the four kinds of teeth named above? Which are fitted for cutting? Which for grinding? Are any suited for tearing? Are any of the teeth pointed? What is the difference in the bicuspid and molars? Are there any decayed places? Are the teeth clean? Are the so-called canine teeth so long that they project beyond the line of the other teeth as they do in a dog? Do the edges of the upper and lower incisors meet when the mouth is closed, or do they miss each other like the blades of scissors? How many roots has each lower tooth? (See Fig. 123.) Which tooth has the longest root?

Care of the Teeth. — The best way to care for the teeth is to *keep the digestion perfect*. Perfect digestion tends to preserve the teeth, and perfect teeth tend to keep the

digestion perfect. The teeth should be *washed regularly*. A *toothpick* is as effective as a toothbrush in keeping the teeth clean. If one eats only soft food, in which the mill and the cooking stove have left no work for the teeth, the teeth will decay; for it seems to be a law of nature that useless organs are removed. The pressure from *chewing hard food is an aid* to the teeth by helping the circulation and nerves in the pulp. To take anything *very hot or very cold* into the mouth may cause the *enamel to crack*. If a tooth aches, or a small decayed place is found in it, a dentist should be consulted at once. A tooth is so valuable to the health that no tooth should be extracted when it can be saved. A good dentist can save a tooth in almost any condition.

The process of digestion consists in making the food soluble that it may pass through the walls of the food tube into the blood, and through the walls of the blood vessels into the tissues. It is accomplished: (1) by *mechanical* means, including the chewing muscles, the teeth, and the muscles in the walls of the food tube; (2) by *chemical* means, or the action of alkalies and acids upon the food; (3) by *organic* agency, or the action of ferments. A *ferment* (or *enzyme*) is a vegetable substance which has the power of producing a chemical change in large quantities of substance brought in contact with it, without being itself changed. There is one ferment secreted in the mouth, two in the stomach, and three in the small intestine.

Digestion in the Mouth.—*Saliva* is formed by six glands: one in the cheek in front of each ear (see Fig. 63), one at the angle of each lower jaw, and one pair is beneath the tongue. Each gland opens into the mouth by a duct. Saliva is *ropy* because it is mixed with mucus

formed by the mucous membrane lining the mouth; it usually contains air bubbles. There is ferment in the saliva called *ptyalin*, which has the power of changing starch to malt sugar. If a bit of bread is chewed for a long time, it becomes sweet, because some of the *starch is changed to sugar*. The flow of saliva is caused by chewing, or by the sight, or even the thought, of agreeable food. Dryness of food is by far more powerful than anything else in causing the saliva to flow. Saliva is deposited



FIG. 124.—CELLS OF A SALIVARY GLAND.

A, after rest, full of granules; *B*, after short activity; *C*, after prolonged activity, cells shriveled and granules lost.

only one fourth as fast when eating oatmeal and milk as when eating dry toast. Starchy grains and fruits were eaten by early man without cooking, and required more chewing than sweet, ripe fruits or oils or proteids. Hence the saliva was given the power of acting upon the starch, for they must remain in the mouth longer. The saliva is alkaline; and if the food is not thoroughly mixed with it, the stomach digestion will also be imperfect, for the alkaline saliva is necessary to excite the flow of gastric juice in the stomach (Fig. 124).

Saliva moistens dry foods which cannot be swallowed, dissolves food that it may be tasted, and aids in the movements of the tongue in speech. Fear prevents its secretion; and the Bible tells of men who could not speak because the "tongue clave to the roof of the mouth."

Chewing gum is a coarse and impolite habit, and wastes the saliva, besides weakening the glands and irritating the stomach by the saliva that is continually swallowed. *Chewing tobacco* has several of these disadvantages, besides allowing the poison in the tobacco to be absorbed by the mucous lining of the mouth.

The **pharynx** (far'inks), or **throat**, is a muscular bag suspended behind the nose and mouth (see Fig. 91, also Fig. 108). There are *seven openings* into the pharynx: two from the nostrils, two from the ears, one each from the mouth, larynx, and gullet. Which of these openings are downward?

The **gullet** (or esophagus) is a muscular tube about nine inches long (see Fig. 108). Like the rest of the food tube, it is lined with mucous membrane. It has two layers of muscles in its walls, the fibers of one layer running lengthwise, and the fibers of the other layer being circular. In *swallowing* the food does not fall down the gullet of its own weight, but is pressed down by the muscles of the gullet. When food enters the pharynx, the muscular walls of the pharynx quickly push it into the gullet. There *the circular bands of muscle in front of the food relax, and those behind it contract and push it on into the stomach*. This action is plainly seen in the neck of a horse when he is drinking water. Both food and water cannot only be swallowed down, but also up, as in vomiting. The gullet is always closed when not in use. See colored Fig. 9; also Photomicrographs, Fig. 73.

Importance of Prolonged Chewing. — Recent experiments at the universities of Yale and Cambridge (England) serve to show that prolonged chewing of food increases *greatly its nutritive power*, so that the amount of food eaten may be diminished by one third without reducing the strength

or weight of the body. By eating very slowly, food is kept in the mouth until all its taste is extracted, making it *the most enjoyable way of eating*. People who eat in this way are found to *have remarkable strength, muscular endurance, and health*, and to have an increase in *self-control* of mind

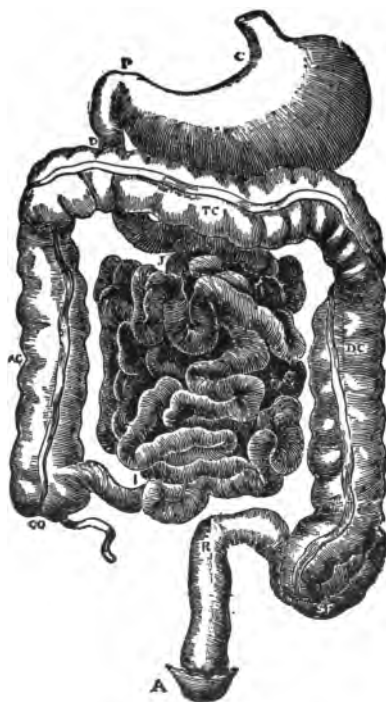


FIG. 125.—THE ALIMENTARY CANAL except mouth and gullet.

C, stomach; P, pylorus; AC, ascending colon; TC, transverse colon; DC, descending colon; SF, sigmoid flexure; R, rectum. The excreta collect in the sigmoid flexure and descend at intervals into the rectum, whence they are removed from the body.

and feelings. They are able to *know the amount and kind of food* that the body needs; these instincts are lost by more hasty eaters. If the eater can only keep his hands lying idly on the table, or in his lap, for a good part of the time, it is easy to eat slowly. *If he puts food into his mouth rapidly it must be swallowed rapidly*. Invalids have regained health by learning to munch their food. Gladstone said jocularly, that every morsel of food should be given thirty-two bites that every tooth might have a chance at it. Without his habit of thorough chewing, it is doubtful whether he would have been able to preserve

his remarkable health and strength to so great an extent as to have been called "the grand old man" at eighty years of age.

The stomach, the greatest enlargement of the food tube, is like *a large bag lying sideways*. It lies to the left side of the abdomen (see colored Fig. 9, also Fig. 125). The walls of the stomach consist chiefly of *muscular fibers which run lengthwise, crosswise, and slantwise*, making three coats. As soon as the food reaches the stomach, the layers of muscles begin to contract, changing the size of the stomach, first in length, then in breadth, thus churning the food to and fro, and mixing it with the gastric juice, a fluid more active than the saliva. For as soon as the food enters the stomach, the mucous membrane lining it blushes a rosy red, and many little gastric glands (colored Fig. 11) in the lining begin to secrete gastric juice.

Experiment 33. Get a piece of tripe from the market. Study its several coats. The velvety inner coat is covered with mucous membrane. See photomicrograph, Fig. 73.

Digestion in the Stomach.—The stomach churns the food from two to four hours after the meal, according to the kind of food eaten, the way it has been cooked, and the thoroughness with which it has been chewed. The *gastric juice* is chiefly water, and contains two ferments called *pepsin* and *rennin*, and a small quantity of *hydrochloric acid*. Rennin acts upon the curd of milk, and is abundant only during infancy. Hydrochloric acid kills germs that may enter the stomach, and changes the food which has been made alkaline by the saliva into an acid condition. This enables the *pepsin to act upon the proteid part of the food*, for pepsin will not act while the food is alkaline. Gastric juice *digests lean meat*, which is a proteid food, by first dissolving the connective tissue that holds the fibers in place, and they fall apart; it then acts upon the fibers separately and makes them soluble. Like

human fatty tissue (Fig. 13), *fat meat* consists of cells filled with fat and held together by threads of connective tissue. The cell walls and the threads, both being proteid, are soon dissolved by the gastric juice, and the free fat is melted into oil, but still undigested. The food is reduced in the stomach to a creamy, half-fluid mass called *chyme*.

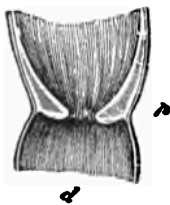


FIG. 126.—PYLORUS.

The Pylorus. — Where the stomach opens into the small intestine, there is a folding in or narrowing of the tube so as to form a kind of valve called the *pylorus* (see Fig. 126). After the food has been changed to chyme, this fold relaxes every minute or two, and allows some of the chyme to escape into the intestine; after several hours it relaxes altogether and allows, not only chyme, but any parts of the food that are still solid, to pass. Before this, anything solid, by touching the pylorus would only have caused it to close more tightly.

The small intestine is about one inch in diameter and twenty feet long, with coils and turns in its course (Fig. 125). Its mucous lining is wrinkled into numerous *folds* in order to increase the secreting and absorbing surface (Fig. 127). On and between the folds are thousands of little threadlike projections called *villi* (Fig. 128). In each villus are found fine capillaries and a small lymphatic called a *lacteal*. The villi are so thick that they make the lining of the intestine like velvet, and enormously increase the absorbing surface.

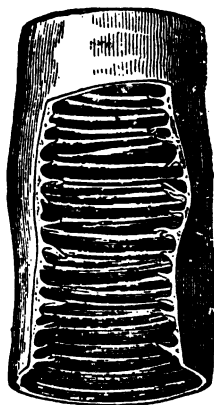


FIG. 127.—A PORTION OF SMALL INTESTINE cut open to show the folds in its lining.

Digestion in the Small Intestine.—This is by far the most active and important of the digestive organs. The mouth digests a small part of the starch, and the stomach digests a small part of the proteid; the small intestine digests most of the starch, most of the proteid, and all of the fats. The food is in the mouth a few minutes, and in the stomach two or three hours; it is in the small intestine ten or twelve hours. There are thousands of small glands called *intestinal glands* that open between the villi (Fig. 128) and secrete the intestinal juice, which digests cane sugar. Besides these, there are two very large and active glands, the pancreas and liver, which are set somewhat apart from the intestine and empty into it by ducts.

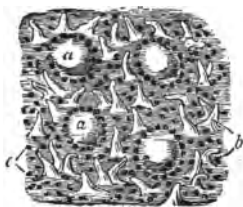


FIG. 128. — LINING OF SMALL INTESTINE, magnified, showing villi and mouths of intestinal glands.

The Pancreas.—The small intestine is the most important of the digestive organs, chiefly because it receives the secretion from the pancreas, the most important of digestive glands. The pancreas is a *long, flat, pinkish gland situated behind the stomach* (see Fig. 120). The pancreatic juice contains *three powerful ferments*, one of which digests the starches, another digests proteids, and the third, with the aid of the bile, breaks up the fats into tiny globules. Fat in small globules floating in a liquid is called an *emulsion*; fresh milk is an emulsion of cream (Fig. 129). Fat is not changed

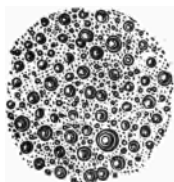


FIG. 129. — A DROP OF CREAM, showing oil globules.

to another substance by digestion, but it is emulsified, and in this condition it readily passes through the walls of the intestines and is absorbed by the lymphatics called *lacteals*,

found in the villi. It then ascends through the *thoracic duct* to a large vein at the left side of the neck (see colored Fig. 15). *The digested proteid, starch, and sugar pass into the capillaries of the portal vein, and go to the liver on their way to the general circulation.* As you learned, the portal circulation empties into the large ascending vein leading to the right auricle.

The Liver.—This large, chocolate-colored gland is located just beneath the diaphragm on the right side (Fig.

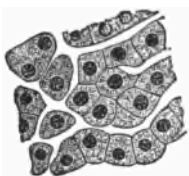


FIG. 130.—LIVER CELLS of a dog after 36 hours' fast (above); also 14 hours after a full meal, digestion finished and cells swollen with liver starch.

120, colored Fig. 16). It is on a level with the stomach, which it partly overlaps in front. The liver has three important functions: (1) *It is a store room*; digested sugar and starch is stored in it as a substance called *liver starch* (or *gly'cogen*, see Fig. 130). (2) *It is a guardian*, and destroys poisonous substances which may be swallowed, and which would otherwise enter the blood. Twice as much poison is necessary to

kill a man when it is given by the mouth and passes through the liver as when it is injected through the skin. Alcohol, morphine, coffee, and drugs are partly burned up in the liver. (3) *It is a gland*, and secretes bile. The bile is made chiefly from waste products and impurities in the blood (see colored Fig. 3); it is an excretion. Although an excretion, it is of great use on its way out of the body. It is alkaline and helps to neutralize the acid in the chyme, it excites the peristalsis, or wavelike motion, of the intestines, and it aids the pancreatic juice to emulsify the fats. See Figures 131 and 132.

The large intestine, or colon, is about two and one half inches in diameter and five feet long. *The small intestine*

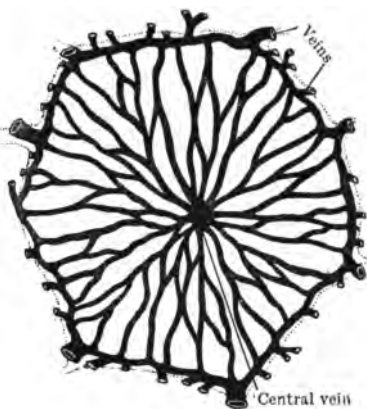


FIG. 131.—VEINS in one lobule of liver. See colored Fig. 3.

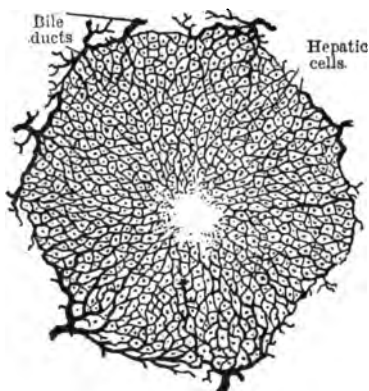


FIG. 132.—BILE DUCTS AND LIVER CELLS in one lobule. (Cunningham.)

joins it in the lower right side of the abdomen (Fig. 125). There is a fold or valve at the juncture, and just below the juncture there is a tube attached to the large intestine, called the *appendix*, which sometimes becomes inflamed, causing a disease called *appendicitis* (Fig. 133). *Absorption* of the watery part of the food continues in the colon, but the colon secretes no digestive fluid. The undigested food and innutritious parts of the food are regularly cast out of the colon. The *peritoneum* is a

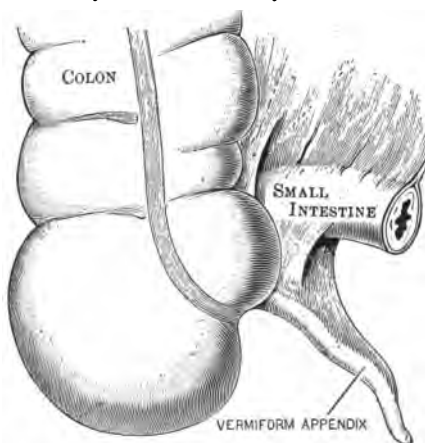


FIG. 133.—JUNCTION OF LARGE AND SMALL INTESTINE.

membrane with many folds that supports the food tube (Fig. 134).

Experiment 34. Make a model of the food tube out of cambric, giving to each organ its correct size.

Absorption.—The way in which the various digested foods are absorbed has been stated in several preceding

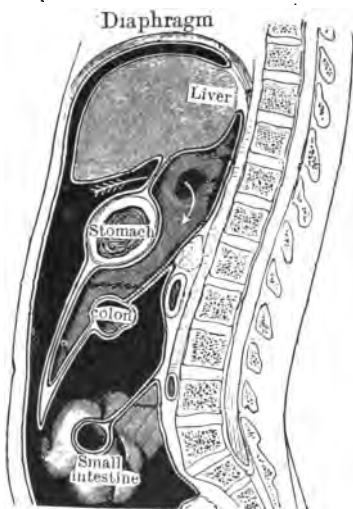


FIG. 134. — DIAGRAM OF TRUNK to show the peritoneum enfolding the abdominal organs. Cut edge of the peritoneum appears as a white line.

topics. What is the name of the organs of absorption in the small intestine? Which of the following pass into the lacteals, and which into the capillaries: sugar, digested proteid, emulsified fats? Water and salt need no digestion, and are absorbed all along the food tube, the absorption beginning even in the mouth. What reasons can you give for the absorption of food being many times greater in the small intestine than in the stomach? Through what important vessel is the fat carried in passing from the lacteals to the veins? Into what large vein do all the capillaries

that take part in absorption empty? (p. 150.) What is the provision for storing the sugar so that it will not pass suddenly into the blood after a meal, but may be given to the blood gradually? Trace the absorption of a piece of bread as given in a previous paragraph.

THOUGHT QUESTIONS.—**The Digestive Organs.** 1. In which of the digestive organs is only one kind of secretion furnished from glands? 2. In which organ are three kinds of secretions furnished by glands?

3. Which class of food goes through the lymphatics? 4. Which classes of foods go through the liver? 5. Which classes of foods are digested in only one organ? 6. Which classes of foods are digested in two organs? 7. Which division of the food tube is longest; broadest; least active; most active? 8. Soup is absorbed quickly; why does eating it at the beginning of a meal tend to prevent overeating?

Some Differences of Opinion about Diet. — Some persons believe that the stomach should be humored and given nothing that it digests with difficulty; others believe that it should be gradually trained to digest any nutritious food that seems to disagree with it. Some believe that no animal food should be eaten; others believe that animal food is the most valuable of all. Some believe that all food should be eaten raw; others believe that raw food is the least valuable of all. Some believe that no form of stimulant, neither tea nor coffee, pepper nor alcohol, should be used; others believe that they are beneficial in moderate amounts. Some eat fast and drink freely at meals; others eat slowly and drink very little or none at all while eating, nor for an hour and a half after a meal. Some eat five meals a day and between meals, if anything that tastes good is offered them; others eat only two or three meals a day, and never between meals, thus allowing the digestive organs time to rest. Some omit breakfast and some omit supper. Some prepare most of the food with grease; others avoid grease almost entirely. Physical workers often believe in eating the peelings and seeds of fruits, and partaking freely of weedy vegetables, such as cabbage, turnip tops, string beans; mental workers usually try to reject all woody fiber and indigestible pulp from the food before swallowing it. Some eat large quantities of food and digest a small portion; others eat little but digest nearly all.

The Power of Adaptation of the Digestive Organs. — Of course some of these ways are better for the health than

others, yet the undesirable ways often bring so little injury that they are not discontinued. This shows that the food tube has great powers of adaptation to different conditions. But there are limits to this adaptation; there is an old saying that what is one man's meat is another man's poison. A brain worker cannot follow the same diet as a field hand without working at a disadvantage. An irritable stomach may be injured by coarse food that would furnish only a healthful stimulus to a less sensitive one. A business man who has little time for dinner should take it after business hours. In general, it may be said that it does not make so much difference *what* is eaten as *how* it is eaten, and *how much* is eaten.

THOUGHT QUESTIONS.—**Indigestion.** I. *A Fetid Breath.* 1. Name three causes of bad breath. 2. Let us investigate whether indigestion could cause a bad breath. In what kind (two qualities) of weather does meat spoil the quickest? 3. Suppose that meat or other food is put into a stomach with its gastric glands exhausted and its muscular walls tired out, what will be the rate of digestion, and what might happen to the food? 4. Odorous contents of the stomach (*e.g.* onion) can be taken by the blood to the lungs.

After answering the above questions, write in a few words how indigestion may cause a bad breath.

II. *A Coated or Foul Tongue.* 1. When the doctor visits you, at what does he first look? 2. What sometimes forms on old bread? (*p.* 125.) 3. Do you think such a growth possible on undigested bread in the stomach? 4. The microscope shows the coating on the bread to be a growth of mold. If it forms on the walls of the stomach, it may extend to what?

III. *Stomach Ache.* 1. How can you tell whether fruit preserved in a sealed glass jar is fermenting? 2. What connection is there between belching at times after eating too freely of sweet or starchy food, and the observation above? 3. A muscle gives pain when it is stretched. Why does belching sometimes give relief to an uneasy stomach? 4. Can you, by using these facts, explain a cause of stomach ache?

For what Kind of Man were the Human Digestive Organs Created?—That food is best to which the food tube has

been longest accustomed. It would be of the greatest value as a guide to diet if we knew the kind eaten by early man during the many ages *when he led a wild life in the open air*. The organs of early man were doubtless perfectly adapted to the life he led. The food tube is adapted to the needs of those long ages; for a few centuries of civilization cannot change the nature of the digestive organs: yet some people disregard natural appetites and try to force the digestive organs to undergo greater changes in a few months than centuries could bring about.

To test whether an Article of Food belonged to Man's Original Diet. — Scientists agree that the human race began in a warm country; that *early man was without grist-mills, stoves, or fire, and ate his food raw*. If an article of food is pleasant to the taste in its raw, unprepared state, there is little doubt that it or a similar food was eaten by primitive man before he knew the use of fire in preparing his food. Apply this test to the following foods, underlining those foods that fail to pass the test: apples, bananas, lettuce, turnip greens, turnips, fruits, nuts, beef, butter, fowls, eggs, oysters, green corn, cabbage, pork, watermelons, grains, crabs, fish, yams, tomatoes.

The Order in which Man increased his Bill of Fare. — Flesh-eating animals have a short food tube, as their food is digested quickly; they have long, pointed teeth for tearing, sharp claws for holding, and a rough tongue for rasping meat from the bones. Man's even teeth, long food tube, soft and smooth tongue, and flattened nails indicate that he is suited for a diet largely vegetable. *The race at first probably ate tree fruits,*¹ both nuts and fleshy fruits. Because of famine, or after migration to colder climates,

¹ See Genesis i. 29.

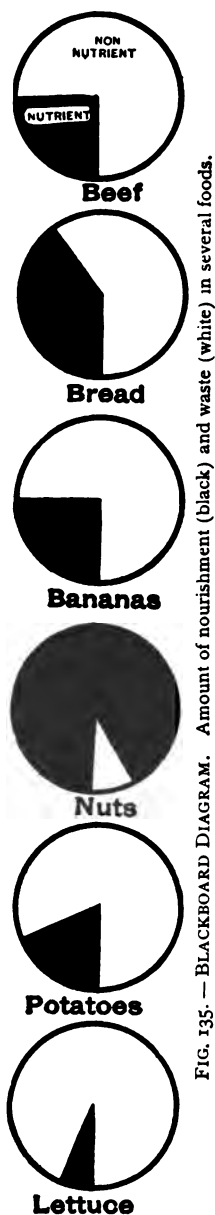


FIG. 135. — BLACKBOARD DIAGRAM. Amount of nourishment (black) and waste (white) in several foods.

and after learning the use of fire, the race probably began to use flesh for food. Afterward the hunters became farmers and learned to cultivate grain, which formed a most important addition to the food supply, and made possible a thick population. Coarse, woody foods, like the leaves and stems of herbs, were probably added last of all. Woody fiber (cellulose) can be digested by cattle, but it cannot be digested by man.

Fruits have the most agreeable of all *flavors*. They contain acids that *kill germs* and keep the food tube pure; they furnish valuable *mineral salts* that are needed by the tissues; they contain *sugar* in its most digestible form (fruit sugar). Since fruit juices kill germs, a fruit diet for a day will often purify the food tube, relieve constipation, and ward off a threatened "bilious" attack. Fruit is pleasanter medicine than drugs and costs less. Green fruit or decayed fruit will cause illness instead of curing it. Fruit contains a large amount of water. *Apples*. — Baked sweet apples are the most digestible of fruits. Ripe sweet apples also digest very quickly. Several apples eaten a half hour before breakfast every morning are more effective medicine than pills, and do not derange the system. The *banana* is,

next to dried figs, raisins, and dates, the most nourishing of all fruits. A pound of bananas contains as much nourishment as a pound of beefsteak (see Table, p. 147). Green bananas taste very good when baked. Bananas are not allowed to ripen on the plant even for use in tropical countries; most fruit is better when so ripened. A banana is usually not thoroughly ripe until its skin is partly blackened. Bananas that show angles were pulled before being full grown, and are not digestible raw. *Peaches* are very wholesome and delicious. Since their season is short, a good supply should be provided by preserving them in cans or glass jars. *Cherries* are more nutritious than apples or peaches. Their flesh is firm, and they should be thoroughly chewed. *Pineapples*, when allowed to mature upon the plant, are a luscious fruit; those shipped to this country are pulled green and are indigestible if eaten raw. *Strawberries* contain much iron. To a few people they are not digestible. *Grapes* are, next to bananas, the most nutritious of fresh fruits (see Table). Their effect on the digestive organs is so beneficial that sometimes dyspeptics try the grape cure, and confine the diet entirely to grapes for several weeks. *Watermelons* are a source of the purest water and a small amount of sugar. The pulp is of tough woody fiber, and if it is removed from the mouth after the juice has been extracted, and it has become a tasteless mass, there is no danger of eating too much watermelon. If the pulp is swallowed, too much may readily be eaten. *Lemons* furnish a pleasant and healthful drink.

Nuts contain less water than other foods, hence they are the *most highly concentrated* and nutritious of all foods (Fig. 135). In the early days of the race they were probably the chief dependence of man. The *oil of nuts* is in a

state of emulsion, or cream, and is much more digestible than fat meat. Since the starch of green nuts is changed to sugar in the ripe nut, the proteid is the only part of the nut that requires real digestion. The *prejudice against nuts* among persons who do not eat properly, or who are ignorant of food values, is due to two causes. First, nuts are eaten after the stomach is full, or they are eaten between meals; second, they are practically indigestible when hastily chewed and swallowed in small bits. *Nuts should be chewed so thoroughly that they are reduced to a creamy pulp before they are swallowed.* The *pecan* contains twice as much fat as ham (see Table); it is the most digestible of all nuts; its kernel has no paperlike skin over it, like the kernel of the almond, hickory nut, etc. Because of the oil in *pecans* they cure and prevent constipation. A pound of *almonds* contains more proteid than a pound of beefsteak, besides two thirds as much fat as a pound of butter (see Table). Which most resembles nuts in composition, beans, peas, or peanuts? Which nut has a composition most like that of grains? (See Table.) *Chestnuts* contain little fat and a very large percentage of starch. They are used for bread in Italy, where they are ground into meal and made into cakes. The *cocoanut* furnishes almost the entire diet in some of the Pacific islands.

Animal Food.—The *flesh* of animals furnishes proteid and fat (Fig. 136). As cooking coagulates and hardens albumin, raw or half-cooked meat is said to be more digestible than cooked meat; but meat that is not thoroughly cooked is dangerous because it may contain the trichina worm and other parasites. There is more proteid in meat than in most vegetable foods, and it is more completely absorbed from the food tube. Some persons who cannot

easily digest starch and sugar because of fermentation eat fat for a fuel food. *Beef tea* and beef extracts contain but a small part of the proteid in meat and all of the waste matter, including urea. *Milk* of cows is improperly called a perfect food by some writers. Although it contains the

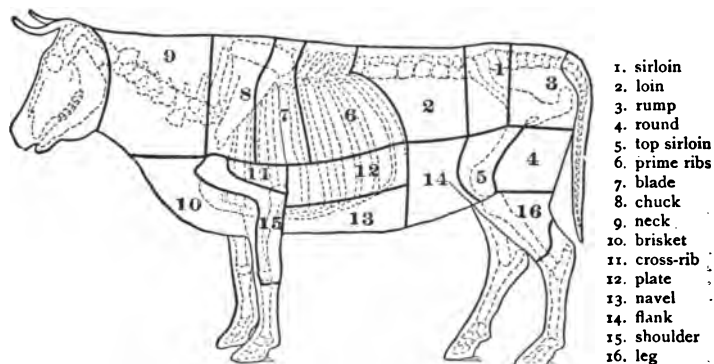


FIG. 136.—DIAGRAM SHOWING CUTS OF BEEF.

four classes of food stuffs, the proteid is in excess, the fuel food being deficient. Water and sugar must be added when it is fed to infants. The first step in digesting milk is the forming of many small curds; hence curds thrown up by an infant do not show indigestion, though it may show that its stomach is too full. Milk was intended to be sucked, not to be drunk in gulps. If adults do not drink sweet milk by slowly sipping, it is likely to form large indigestible curds causing "biliousness" and constipation. Sour milk, or "clabber," and curds pressed into "cottage cheese" are more digestible than sweet milk. *Cream* is more easily digested than *butter*, which is a solid fat. It hardly seems logical to spend a long time churning milk, which is an emulsion, in order to cause the particles of cream to adhere into a solid fat, and then to eat the butter and let the food tube spend

several hours reducing it to an emulsion again. It is necessary to churn cream into butter for convenience in shipping, and because it keeps fresh longer; but for those who can obtain fresh cream, it may well be eaten instead of butter, being used as "whipped cream" and in other ways. *Cheese* is a very concentrated proteid food, and should be eaten sparingly. *Eggs* are a very valuable food. What part of the egg contains proteid? Is there more proteid or fat in eggs? (See Table.) Pork and veal are the most indigestible of meats. *Fish* is not so nutritious nor so easily digested as meat. There used to be a supposition that fish nourished the brain because it contains phosphates; but there are more phosphates in meat than in fish, and more in grains than in meat.

Grains contain considerable proteid (gluten), but they especially abound in starch. Wheat flour contains more gluten than corn meal, hence it is more sticky and retains the bubbles of gas so that the dough rises well in bread making. Eggs are sometimes added to corn meal to make it sticky and cause it to rise well. Which grain has the largest percentage of oil? Of starch? Of gluten? Which is poorest in gluten? *Grains may be made to resemble fruit* by long cooking at a high temperature (300° Fahr.), for their starch is thus changed to *dextrin*, a substance resembling sugar. You learned that the starch of fruit is turned into sugar as the sun ripens it. Dextrin is yellow and gives the dark color to toasted bread. It is changed to sugar almost instantly when brought in contact with saliva. It is used as a paste on postage stamps.

Vegetables include the stems, roots, and leaves of plants. With the exception of beans, peas, and potatoes, vegetables are the least nutritious class of food; for example, onions, celery, lettuce, turnips, carrots, green salads (Fig. 137).

Cabbage contains a small amount of starch (see Table), but it is slowly digested and this small nourishment hardly atones for its exhausting effect upon the organs. The sulphur in it gives it an odor which can be detected upon the breath until it leaves the stomach; often this is

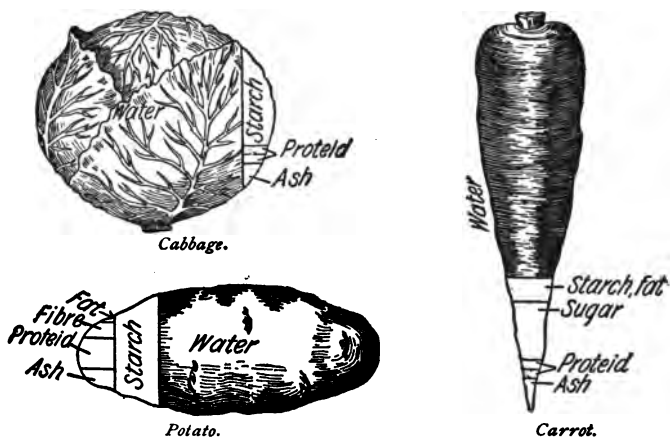


FIG. 137. — SHOWING COMPOSITION OF POTATO, CABBAGE, AND CARROT. (Jegi.)

many hours after it has been eaten. *Vegetables are composed chiefly of water and woody fiber.* Irish potatoes are underground stems and are *one fifth starch*. Yams, or sweet potatoes, resemble roots, and contain both starch and sugar. *Beans and peas are very nutritious.* They have been called “the lean meat of the vegetable kingdom.” They require boiling for several hours. If the skins are removed by pressing them through a colander, they are very easy of digestion. “Hull-less beans” are also sold by grocers.

PRACTICAL QUESTIONS. — 1. Clothing and shelter for man or beast economize what kind of food? 2. Why should bread remain longer in the mouth than meat? 3. In snowballing, what is the appearance of the hands when they itch from cold? Extreme cold irritates

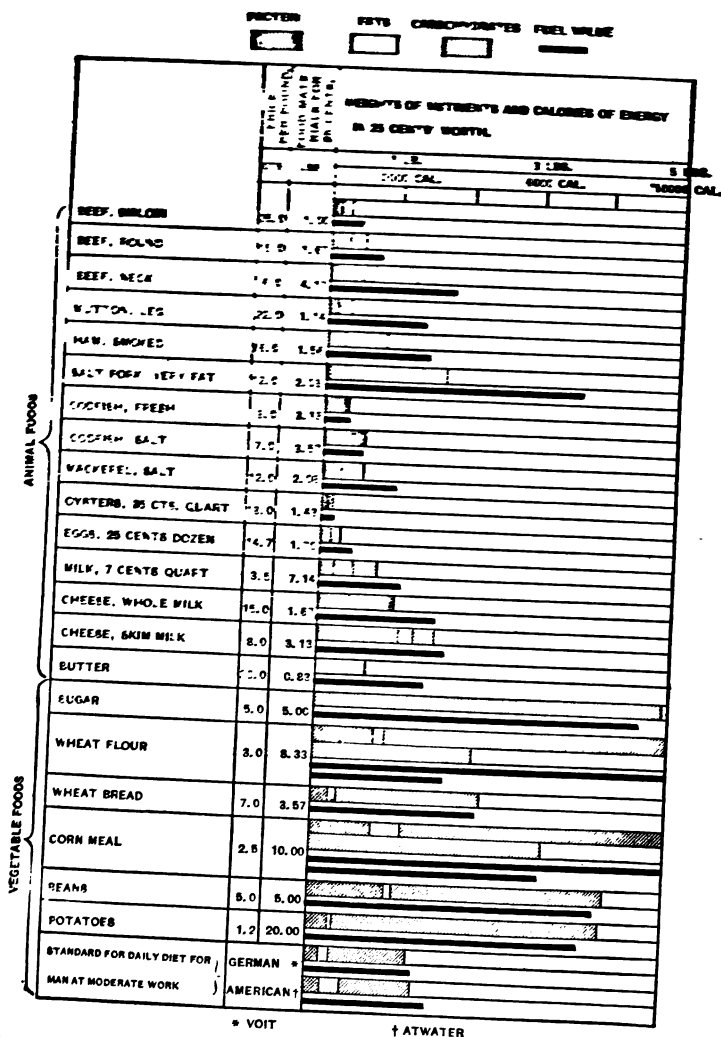


FIG. 138. — NUTRIMENT IN TWENTY-FIVE CENTS' WORTH OF VARIOUS FOODS.

Which food in the table is the dearest; the cheapest? What are the three dearest; the three cheapest? Which food furnishes the most proteid for twenty-five cents; the most fat; carbohydrates (sugar and starch)? Compare cost of animal and vegetable foods.

and congests the stomach more quickly than it does the hands. Why is it that ice water does not satisfy the thirst, but often produces a craving to drink more water? 4. Should biscuits having a yellow tint or dark spots due to soda be eaten or thrown away? 5. Why, during an epidemic, are those who have used alcohol as a beverage usually the first to be attacked? 6. Do you buy more wood (cellulose) when you buy beans or when you buy nuts? (p. 147.) 7. Do you buy more water when you buy bread or when you buy meat? 8. Why do people who live in overheated rooms often have poor appetites? (p. 138.) 9. Explain how the stomach may be weakened by the eating of predigested foods. 10. Why is deep breathing and exercises that strengthen weak abdominal walls better for the liver than are drugs? (See p. 87.) 11. Sixty students at the University of Missouri found by doing without supper that their power to work was greater, their health better, and many of them gained in weight. So they only ate two meals thereafter. If sixty plowboys tried the experiment, would the result probably have been the same? 12. If a person began to eat less at each meal, or only ate one meal a day, yet gained in weight, should he agree with a friend who told him he was starving himself? Should he agree if, instead of gaining, he lost weight? 13. Why is half-raw or soggy bread harder to digest than the raw grain itself? Which would be thoroughly chewed and cause a great flow of saliva?

Professor Atwater's Experiments.—A few years ago Professor Atwater proved that if alcohol is taken in small quantities, it is so completely burned in the body that not over two per cent is excreted. He inferred that it is a food since it gives heat to the body and possibly gives energy also. Dr. Goddard has since made experiments on dogs and found that seventy-five per cent of it was oxidized in the body if only moderate doses were given; if large doses were given, fifty per cent was excreted unchanged.

What Professor Atwater's Experiments failed to Show.—His experiments were tried on persons who were accustomed to using alcohol. They failed to show what the effect would be on human beings with perfectly natural bodies unaccustomed to defending themselves against alcohol; the experiments also failed to show whether in

burning up the alcohol any organ was weakened or injured thereby. As alcohol is chiefly burned in the liver, it probably cannot supply energy as is the case with food burned in nerve cell and muscle cell. Even the heat supplied by its burning is chiefly lost by the rush of blood to the skin usually caused by drinking the alcohol.

Dr. Beebe's Experiments have supplied Some of the Missing Knowledge. — Dr. Beebe, unlike Professor Atwater, experimented upon persons who had never taken alcohol, and whose bodies had not had time to become trained to resist its evil effects. He found that owing to what Neumann calls its action as a protoplasmic poison, it caused an increased excretion of nitrogen. When the body became used to it this decreased, but the proteid excreted by the kidneys contained an abnormal amount of a poisonous material called *uric acid*. Now uric acid, a substance which causes rheumatism and other diseases, is usually destroyed by the liver. As the burden of destroying the alcohol falls chiefly upon the liver, it is not surprising to find that it is so weakened and injured by alcoholic drink that it cannot perform fully its important function of destroying uric acid. It is also plain why rheumatism, Bright's disease, and other diseases accompanied by uric acid are so frequent among persons who use alcoholic drinks.

Definition of Food. — *A food is anything which, after being absorbed by the body, nourishes the body without injuring it.* Alcohol does not come within this definition.

Advantages of Good Cooking. — Taste and flavor may be developed; parasites are killed; taste may be improved by combining foods; starch grains are burst and the food softened. Food well cooked is already partly digested.

Disadvantages of Bad Cooking. — Proteid foods are hardened; flavors may be driven off; too many kinds of food

may be mixed; cooked vegetables are more likely to ferment than raw vegetables; palatable food may be made tasteless or soggy or greasy; soda and other indigestible ingredients may be added; food may be so highly seasoned as to cause catarrh of the stomach; it may so stimulate the appetite that so much is eaten as to overload the stomach. Food may be made so soft that it cannot be chewed, and is eaten too rapidly; for instance, bread shortened with much grease.

The Five Modes of Cooking. — Food may be cooked (1) by *heat radiating from glowing coals* or hot metal or a flame; (2) by *hot air*, as in a hot oven; (3) by *boiling in hot water or grease*; (4) by *hot water*, not boiling, as in stewing; (5) by *steaming*.

Radiant Heat. — *Toasting* bread and *broiling* meat are examples. The meat should be turned over every ten seconds to send its juices back and forth, thus preventing their escape, and broiling the meat in the heat of its own juices. *Roasting* is an example of this method combined with the second method. The fire should be hot at first in order to sear the outside of the meat and prevent the escape of its juices. If the piece roasted is small, the hot fire may be kept up; but if it is large, a longer time is required, and the fire should be decreased, otherwise the outside will be scorched before the central part becomes heated. Irish potatoes, roasted with their skins on, retain their flavor better than by most methods of cooking them.

Cooking by hot air can only be used with moist foods. Baking is an example. Foods only slightly moist are made hard, dry, and unpalatable if cooked by this method.

Cooking by Boiling. — To boil *Irish potatoes* and make them mealy instead of soggy, the water should be boiling when they are put in, and after they are cooked the water

should be poured off and the pot set on the back of the stove for the potatoes to dry (Figs. 139, 140). Boiling *onions* drives off the acrid, irritating oil. Raw *cabbage* is



FIG. 139.—CELLS OF RAW POTATO with starch grains inclosed in the cellulose walls.



FIG. 140.—CELLS OF POTATO well steamed and mashed. Starch grains have been burst by the heat.

treated by the stomach as a foreign substance, and sent promptly to the intestine; cabbage boiled with fat remains in the stomach for five hours. Instead, it should be boiled in clear water for twenty minutes. *Beans* and *peas* require long boiling.

Cooking in hot liquid below the boiling point is better than boiling. In *frying* meat, it should be put in hot grease that a crust may be formed to prevent the grease from soaking in. Overheated grease becomes decomposed into fatty acids and other indigestible products. In whatever way meat is cooked, it should never be salted until it is cooked, or the salt will draw out the juices which flavor it. *Eggs* may be cooked by placing them in boiling water and

setting the kettle off the stove at once to cool. Since boiling for more than a very few minutes coagulates and hardens albumin, there is no such thing as boiling meat without making it tough and leathery throughout. It may be stewed, a process which belongs to the next method.

In **stewing meat**, it may be plunged into boiling water for a few minutes; this coagulates the albumin on the surface. The fire should then be reduced, or the vessel set on the cooler part of the stove, or a metal plate should be placed beneath it, that the water may barely simmer.

The water should show a temperature of 185° or 190° if tested with a thermometer. A piece of meat cooked in this way is tender and juicy throughout.

Cooking by steam requires a double vessel or a vessel with a perforated second bottom above the water, through which the steam may rise to the food that is to be steamed. *Steamed vegetables* have a better flavor than those cooked in any other way. *Oatmeal* should be cooked for at least forty minutes, and it is more digestible if steamed for several hours until it is a jelly. To do this, it may be cooked during the preparation of two meals. Cooking that leaves it lumpy and sticky is a disadvantage, and makes it more likely to ferment than if eaten raw.

THOUGHT QUESTIONS. — **Cooking. Meat.** 1. In making soup, why should the meat be put in while the water is cold? 2. In roasting meat, why should the oven be hot at first, and more moderate afterward? How should you regulate the temperature in boiling or stewing meat? 3. What happens to salt or anything salty on a cloudy, damp day? This is because the salt attracts —. This shows that meat should not be salted until after it has been cooked, because if salted before, the salt will — the juices. 4. Very tough meat should be b—ed or st—ed. 5. Meat is allowed to become grease-soaked when it is — by — cooks. This may be prevented by having the grease very —, use very —, simply greasing the —.

6. *Bread.* Bread crust causes the — to be used more and cleans them. It will not — together in the stomach like the crumb. It increases the quantity of the —, and is more digestible than the crumb, since the — has been changed by slow heat to —. (p. 172.) Therefore loaves or biscuit should be [large or small ?] and they should [touch or be separated ?] in a pan. 7. How can you tell whether the oven has been too hot while the bread was baking? 8. Why can you tell best about the digestibility of bread when you are slicing it? 9. Regulating the heat is the greatest art of the cook. How may the temperature of the oven be lowered by means of the damper? The draft? The fuel?

EXERCISES IN WRITING. — Story of a Savage who went to dwell in a City (his trouble with artificial ways). Is it easier to learn Physiology or to practice it? How to make Bread. Describe People seen

in an Audience (tell what their appearance suggests). A Scene at a Dinner Table. Thoughts of a Physician on his Round of Visits. Prejudices concerning Food. A Good Cook. A Bad Cook. Is Cooking a Greater Accomplishment than Piano Playing? Common Causes of Illness. The Home of a Reformed Drunkard. Alcohol and Duty to Parents. A One-armed Man (loss of arm due to drink). The Influence of Imperfect Digestion upon the Other Organs. What the Blood does for the Body. Effect of Lack of Muscular Activity. The Way of the Transgressor is Hard. What Fools we Mortals be! Health Fads. Temperance in all Things. The Right Way the Easiest. Looking Back. Looking Forward. Hygiene of the Schoolroom. Patent Medicines. Microbes. Mind Cure. Nervous Women. Dissipated Men. How a Friend of mine lost his Health. Why a Friend of mine is Sound and Strong. Useful Labor. Tobacco. It never pays to neglect the Health. Which does more Harm, an Ignorant Cook, or an Ignorant Janitor? A Visit to a Sick Room. Why I believe in Games. Write a Letter to a Friend upon meeting a Mutual Schoolmate who took to Drink. Alcohol and Crime. Natural Instincts and Appetites: how preserved, how lost. A Lesson about Alcohol based upon the Morning News. Effects of Alcohol upon the Greatness of our Country (workmen, voters, soldiers, children).

Physicians and Alcohol.—Three times during the last century medical manifestoes were issued giving the opinion of physicians on alcohol. The first was issued in 1839, and was signed by eighty-six persons. The second was in 1847, and was signed by two thousand physicians, and the third appeared in 1871, with the signatures of over four thousand physicians, including the names of many leading physicians in all parts of the world. A fourth declaration of opinions, which has already received several thousand signatures, is now (1905) being circulated and reads as follows:—

“The following statement has been agreed upon by the Council of the British Medical Temperance Association, the American Medical Temperance Association, the Society of Medical Abstainers in Germany, and leading physicians in England and on the continent. The purpose of this is to have a general agreement of opinions of all prominent physicians in civilized countries concerning the dangers from alcohol, and in this way give support to the efforts made to check and prevent the evils from this source.

“In view of the terrible evils which have resulted from the consumption of alcohol, evils which, in many parts of the world, are rapidly increasing, we, members of the medical profession, feel it to be our duty, as being in some sense the guardians of the public health, to speak

plainly of the nature of alcohol, and of the injury to the individual, and the danger to the community which arise from the prevalent use of intoxicating liquors as beverages.

"We think it ought to be known that:—

"1. Experiments have demonstrated that, even a small quantity of alcoholic liquor, either immediately or after a short time, prevents perfect mental action, and interferes with the function of the cells and tissues of the body, impairing self-control by producing progressive paralysis of the judgment and of the will, and having other markedly injurious effects. Hence, alcohol must be regarded as a poison, and ought not to be classed among foods.

"2. Observation establishes the fact that a moderate use of alcoholic liquors, continued over a number of years, produces a gradual deterioration of the tissues of the body, and hastens the change which old age brings, thus increasing the average liability to disease (especially to infectious diseases) and shortening the duration of life.

"3. Total abstainers, other conditions being similar, can perform more work, possess greater powers of endurance, have on the average less sickness, and recover more quickly than non-abstainers, especially from infectious diseases, while they altogether escape diseases specially caused by alcohol.

"4. All the bodily functions of a man, as of every other animal, are best performed in the absence of alcohol, and any supposed experience to the contrary is founded on delusion, a result of the action of alcohol on the nerve centers.

"5. Further, alcohol tends to produce in the offspring of drinkers an unstable nervous system, lowering them mentally, morally, and physically. Thus, deterioration of the race threatens us, and this is likely to be greatly accelerated by the alarming increase of drinking among women, who have hitherto been little addicted to this vice. Since the mothers of the coming generation are thus involved, the importance and danger of this increase cannot be exaggerated.

"Seeing, then, that the common use of alcoholic beverages is always and everywhere followed, sooner or later, by moral, physical, and social results of a most serious and threatening character, and that it is the cause, direct or indirect, of a very large proportion of the poverty, suffering, vice, crime, lunacy, disease, and death, not only in the case of those who take such beverages, but in the case of others who are unavoidably associated with them, we feel warranted, nay, compelled to urge the general adoption of total abstinence from all intoxicating liquors as beverages, as the surest, simplest, and quickest method of removing the evils which necessarily result from their use. Such a course is not only universally safe, but is also natural.

"We believe that such an era of health, happiness, and prosperity would be inaugurated thereby, that many of the social problems of the present age would be solved."

REVIEW QUESTIONS. — Chapter VII. 1. What is the source of the heat of the body; its energy; its growth? 2. What is digestion; assimilation; oxidation; excretion; nourishment; nutrition? 3. Trace energy through several changes of form. 4. Why must heat be constantly generated in the body? How is the fuel stored? 5. Mention several kinds of oxidation. 6. Give an idea of the amount of heat and work produced by the body in one day. 7. Compare the body with a steam engine as a machine for doing work. 8. Show how plants support animal life. What enables them to do this? 9. Does a plant, or an animal, store up energy? Which expends the energy? 10. Describe the changes that take place in a body deprived of food.

1. Name the four kinds of food stuffs. Which two are classed together as fuel foods? 2. Which food builds tissue? 3. Which foods aid these two classes in their work? 4. Why is proteid so important among food stuffs? 5. Name the sugars with their sources. 6. State the sources of fat. 7. Name the several forms of proteids with their sources. 8. Show the importance of taking plenty of water. 9. Name the three chief wastes resulting from the vital processes, and the organs which excrete each of them. Why is undigested material rejected by the alimentary canal classed apart? 10. Name the sources of plant food; animal food; mineral food.

1. What weights of proteid and fuel foods are needed to replace the daily waste? 2. When is appetite a perfect guide? 3. What are the undesirable extremes in selecting food? 4. How may intelligence be a source of economy in providing food? 5. Why is excess or lack of proteid worse than excess or lack of fuel food? 6. How much (1) proteid, (2) fat, (3) sugar and starch are needed in the ration? 7. If there is one fourth ounce of proteid in an ounce of beans, what weight of beans must be eaten to obtain four ounces of proteid? If there is one fifth of an ounce of proteid in an ounce of lean beef, how many ounces of beef would furnish as much proteid as eight ounces of beans, so as to replace half the beans with beef? Name starchy and oily foods which might be used to complete the ration. 8. How do the following peoples obtain the right proportions of the food stuffs: Scotch; Irish; Mexicans; Arabs; Asiatics? 9. Give a summary of digestion in the mouth, stomach, and small intestine. 10. Name two parts of the alimentary canal in which there is no digestion. 11. Trace a piece of bread from the time it is eaten until it is assimilated in the cells. 12. Does hunger show the condition of the stomach or of the

cells in general? **13.** Describe the parts of which a tooth is composed. **14.** Name the teeth in one quarter of the mouth in order from the front. Which teeth are lacking in the temporary set? **15.** What do you learn by studying the teeth in a mirror? **16.** What conditions favor the preservation of the teeth?

1. Name the mechanical, chemical, and organic agencies in digestion. **2.** What is the ferment in saliva? How much faster does saliva flow for dry food than for moist food? **3.** What are the objections to chewing gum; chewing tobacco? **4.** Describe the pharynx. Name its seven openings. **5.** Describe the gullet; the act of swallowing. **6.** Describe the advantages of munching the food, as shown by recent investigations on the subject. **7.** Describe the structure and muscular action of the stomach. Describe the gastric glands. **8.** State the work done by each part of the gastric juice. **9.** Describe the action of gastric juice upon lean meat; fat meat. **10.** What is the condition of each food stuff when the food has been changed to chyme? **11.** Describe the action of the pylorus. **12.** What is the structure of the small intestine? **13.** Show that it is the most important of the digestive organs. **14.** Describe the pancreas and the action of its ferments. **15.** How is fat emulsified and absorbed? **16.** How are digested proteid and sugar absorbed? **17.** What is the position of the liver? What are its functions? **18.** Trace the course of the colon (Fig. 125). **19.** Give differences of opinion about humoring the stomach; raw foods; stimulants; drinking at meals; times for eating; quantity of food, etc. **20.** Why should not all people eat the same kind of food?

1. Man's food tube was originally designed for what kind of man? **2.** What is a simple test whether a food was eaten by early man? **3.** What food was the principal support of early man? In what order were the other foods added to his diet? **4.** State four valuable qualities of fruits as food. Repeat what is said of apples; bananas; peaches; cherries; pineapples; strawberries; grapes; watermelons. **5.** Are nuts very nutritious? Their oil is in what state? Give two reasons for prejudice against them. What is said of pecans; almonds; chestnuts; cocoanuts? **6.** Why should meat be thoroughly cooked? Discuss beef tea; milk; butter; cheese; eggs; fish. **7.** Grains are of value for what two food stuffs? What is the effect of prolonged cooking of grains? **8.** Discuss the food value of the various vegetables. **9.** Give the advantages of good cooking and the disadvantages of bad cooking. **10.** What are the five modes of cooking? Describe the five methods, with the precautions to be observed in using each method, and the foods suitable to be cooked by each method.

CHAPTER VIII

THE NERVOUS SYSTEM

Review Questions introducing this Subject.—What is a cell? What are the five supporting tissues? What are the two master tissues? Why are they so called? Will muscles contract by their own action alone? What kind of cells have many branches? Where is the greatest collection of nerve cells placed, and what is it called? Does the food ever come in contact with the salivary glands? When you look at a basket of apples, the sight “makes your mouth water.” There must have been a connection between the eye and the mouth. What makes this relation possible? What two tissues enable the skin to blanch and to blush? Do the different organs share the blood in the same proportions at all times? How can this proportion be changed? How is the brain protected from injury? How is the spinal cord protected? Is the hole for the spinal cord through the main body of the vertebra, or behind the main body?

An Instance of the Wonderful Harmony of the Bodily Functions.—When one uses the muscles of the legs in running rapidly, before he has gone many steps the lungs begin to expand with deep breaths in order to supply more oxygen to the active muscles. The heart soon pumps more vigorously to send the blood bearing this oxygen to the place where it is needed. The great oxidation going on in the muscles of the runner tends to overheat the body, so before many minutes have passed the sweat tubes begin to pour out the perspiration which, by its evaporation, cools the body. If the runner keeps on running so long that the lungs and heart cannot keep up a sufficient supply of oxygen to replace the large amount so rapidly consumed, the muscles begin to ache and the

runner is warned that he must stop, or be in danger of straining or injuring some part of his body. This beautiful harmony in the work of the various organs is made possible by the nervous system.

Other Examples of this Harmony.

— Strike suddenly at the eye of another, and the lids fall to protect it, and the hands rise to ward off the blow. If a grain of dust gets into the eye, the tear glands form tears to wash it out. If you touch the hand unexpectedly to a hot iron, the muscles of the arm jerk the hand away. Tickle the foot of a sleeping person, and the muscles of the leg pull it away. If the human being were merely an assemblage of working organs, these organs might act independently, and there would be such confusion that the body would be powerless, and would soon go to pieces. It is fortunate that a means is provided to make the organs work together for the common good (Fig. 141).

The Need of Nerve Centers as well as Nerves. — If there were no cen-

tral office in a telephone system of one thousand subscribers, then every subscriber, in order to communicate with every other subscriber, would need one thousand wires running into his house; all together, there would



FIG. 141. — LARGER NERVES
near surface of right arm.

have to be several hundred thousand (499,500) wires. With a central office only one thousand are needed.

As a telephone system has central offices, so our nervous systems have nerve centers. Nerve centers contain nerve cells. Although there are some subordinate nerve centers in the spinal cord, the great nerve center of our bodies is in the skull, and is called the *brain*. Without nerve centers the nervous system would not deserve the name of system.

The nervous system, unlike a telephone system, has other duties besides allowing *communication*. It enables us to *think*, and after reflection, to *will* and to *act* by controlling the various organs.

The Units of which the Nervous System is Constructed.—A nerve cell with all its branches, or fibers, is called a *neuron* (see Fig. 142). Neurons are the units that compose the nervous system. You learned that the living substance in cells is called protoplasm. The cell branches, or fibers, contain an almost transparent, jellylike protoplasm, possessing the most marvelous and varied powers of any known substance, for the nerve cells are the seat of the mind.

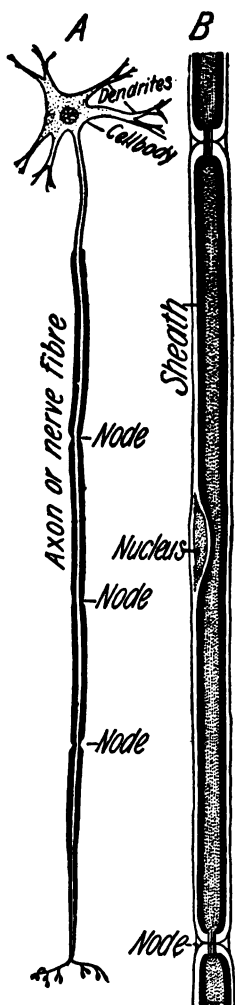


FIG. 142.—Showing a NEURON, A, or nerve cell with all its parts—dendrites, cell body, and axon; B, a portion of a white fiber highly magnified. (Jegi.)

Nerve Cells and Fibers.—The many branches of nerve cells make them the most remarkable of all cells for irregularity in shape. Since *the protoplasm of the cell continues into the fibers*, it is plainly wrong to consider the nerve cell as something apart from its fibers. It is not a complete cell without them. A cell usually has many short branches called *dendrons* or *dendrites* (see Fig. 142) for communicating with near-by cells, and one long branch called an *axon* (Fig. 142) for communicating with distant parts. The axons form the fibers that go to the skin, muscles, and other organs. The long axons go all over the body and are often bound together into visible cords called *nerves*, or nerve trunks (see Fig. 75, photomicrographs, p. 77).

As the various parts of a city are in communication by means of telephone wires, the different parts of the body are in constant communication by means of these living threads. The nerve cell which sends the impulse corresponds to the battery which sends the electricity; the nerve fiber corresponds to the wire.

White and Gray Fibers (Fig. 143).—If a fiber has a *fatty covering* surrounding the *thread of protoplasm*, it is white and glistening, and is called a *white fiber*. If it is without this fatty covering, it is gray in color and is called a *gray fiber*. Both kinds of fibers have *connective tissue* on the outside to strengthen them. If we let a lead pencil represent a white fiber, the lead corresponds to the core, or axis, of protoplasm; the wood corresponds to the white, shiny fat that surrounds it; and the varnish corresponds to connective

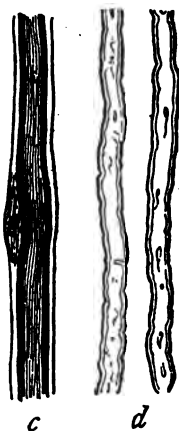


FIG. 143.—c, a white fiber with its fatty sheath (dark); d, two gray fibers (without sheath).

tissue on the surface of the fiber. A number of white fibers together make a white mass that is called *white matter*. The axis of a white fiber, of course, is not white. A mass of cells or of gray fibers is called *gray matter*.

Feeling Cells and Working Cells. — Nerve cells may be divided into two classes: *sensory cells*, which feel or receive impressions; and *motor cells*, which send out impressions to the working organs. Those fibers which carry impressions to the receiving cells are called *sensory fibers*; those which carry impulses from the cells to the working organs are called *motor fibers*.



FIG. 144. — A GANGLION.

A. Ganglion and a Nerve Center. — Nerve cells are not scattered uniformly in nervous tissue, but are gathered into groups. A group of nerve cells is called a *ganglion* (Fig. 144). One or more ganglia having a single function, such as to control the muscles of breathing, form what is called a *nerve center*. The brain consists of a number of nerve centers with their connective fibers.

Structure of the Spinal Cord. — The nerve fibers from nearly all over the body lead to cells situated in a large cord in the spinal column called the *spinal cord*. The spinal cord is *separated by a deep fissure almost into halves* (Fig. 145). The cells are situated in the central portion of each half, and the *two masses of gray matter* thus formed are connected by a narrow isthmus of gray matter. The outer part of the cord consists chiefly of white fibers. The *white matter is thus on the outside of the cord* (Fig. 145). The brain, unlike the cord, has the

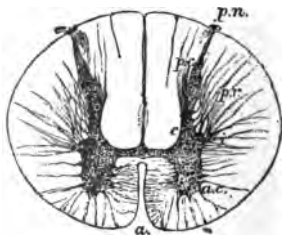


FIG. 145. — CROSS SECTION OF SPINAL CORD, showing area of gray matter (dark).

gray matter on the outside and the white matter on the inside.

The Work of the Spinal Cord. — There are two functions of the cord: reflex action and transmission of impulses from the body to the brain. Reflex action is action that takes place without the aid of the will.

Reflex Action. — This action never begins in the cord, but at the outer end of a sensory fiber, usually located in the *skin*. The impression goes to the cord along a *sensory fiber*. It is received in a *sensory cell* and transferred to a *motor cell* which sends back an impulse along a *motor fiber* to a *muscle*; the muscle contracts and the action is complete (see Fig. 146). There are always two nerve cells concerned in every reflex action.

The greater part of the nervous energy expended in the body is used in producing the numberless reflex actions.

Reflex Action, Consciousness, and Will. — Usually not all of the force of the impulse is transferred to the motor cell. The sensory cell by means of another of its many branches may *transfer part of the impulse to a cell which sends it to the brain*. Hence a reflex act is not necessarily an unconscious one. If you unintentionally touch the hand to a hot stove-pipe, you may be conscious of the pain and the involuntary jerking away of the hand at the same time. Reflex action takes place during sleep as readily as when we are awake. This may be proven by tickling the foot of a sleeping person. Sometimes the will may *inhibit* or prevent a reflex act. Many reflex acts occur in spite of the effort of



FIG. 146. — NERVE CURRENT IN REFLEX ACTION, showing that two cells are necessary for it.

the will to prevent them. You cannot always keep from closing your eyes when some one strikes at you, even if from the other side of a plate glass window, and you know there is no danger. Sneezing is a reflex act and you cannot prevent it, even if you try to do so for fear of disturbing the sleep of another. The forming of saliva and other secretions are reflex acts. *Reflex acts are quicker than*

conscious acts. An eighth of a second is about the time required for a person to press an electric button after seeing a signal; a reflex act may occur in a shorter time.

The Brain consists of Three Chief Parts.

—(1) There is an enlargement at the top of the spinal cord called the *medulla*, or the medulla oblongata. It may be looked upon as the part of the spinal cord within the skull (see Figs. 147, 148, 153). (2) Above the medulla is the *cerebellum*, or little brain. (3) The *cerebrum*, or large brain, fills all the skull except the small part occupied by the medulla and cerebellum. Does the cerebrum cover the cerebellum on top? (See Figs. 147, 148.)

The work of the medulla is chiefly to control the vital functions (see Figs. 148, 153). Here are located the centers for regulating the *breathing*, the *heart beat*, the *size of the blood vessels* (thus regulating nutrition),

and also the less important centers that control *swallowing*, *secretion of saliva*, and *vomiting*. The center for breathing is sometimes called the *vital knot*, because although the cerebrum and cerebellum may be removed from an animal



FIG. 147. — BRAIN AND SPINAL CORD.

without causing immediate death, the slightest injury to the vital knot kills the animal at once. In cases of hanging, death is caused by injury to this center.

Automatic Action. — The center called the vital knot is not said to regulate the breathing reflexly, but automatically. Reflex acts start in the skin; *automatic acts start in the interior of the body. The condition of the blood regulates the breathing* automatically. If too much carbon dioxid accumulates in the blood, this excites the vital knot which sends out stronger impulses to the respiratory muscles. Deeper breathing follows, which purifies the blood, and the breathing is then quiet until an excess of carbon dioxid occurs again.

The *cord* controls chiefly *reflex* action; the *medulla* controls chiefly *automatic* action; the *cerebellum* controls chiefly *coördinate*, or harmonizing, action; the *cerebrum* controls the purely *voluntary* acts, for it is the seat of *consciousness* and *thought*. The medulla, like the cord, has the gray matter on the inside (Fig. 147).

Structure of the Cerebellum.

—The cerebellum, like the cerebrum, has the gray matter or cells on the outside. The gray matter is folded into furrows that are not nearly so winding as the folds in the cerebrum (see Fig. 154). The fibers

going to the surface cells have a branched arrangement called the *arbor vitæ*, or tree of life, which is shown where the cerebellum is cut. The cerebellum, like the cerebrum, is deeply cleft and thus divided into halves, called *hemispheres*, connected by a band of white matter.



FIG. 148. — THE BRAIN (cerebrum, cerebellum, medulla).

The work of the cerebellum is to aid the cerebrum in controlling the muscles. *It coördinates the muscular movements*, that is, it makes the muscles act at the right time and with due force in complex acts, such as standing, walking, talking. A man could strike just as hard without the action of the cerebellum, but he would not be likely to hit what he aimed at. A drunken man staggers and fails to control the muscles in walking because the alcohol has caused the blood to collect and congest around

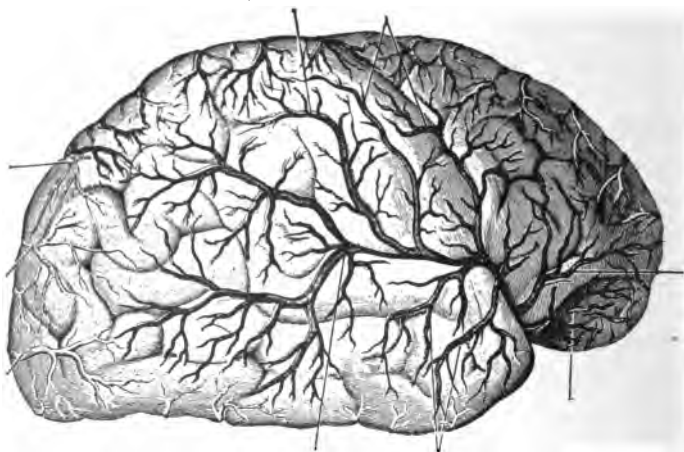


FIG. 149.—ARTERIES on the surface of the cerebrum. (Cunningham.)

the cerebellum and press upon it. When the cerebellum of a person is injured by accident, he staggers like a drunken man.

Structure of the Cerebrum.—Lining the skull and covering the cerebrum are found *several membranes* which inclose a lymphlike fluid. Thus a kind of *water bed* is made which surrounds the soft and delicate cerebrum and protects it from jars. Within the membranes are numerous blood vessels which plentifully supply the cerebrum with blood (Fig. 149). The gray matter, or cell mass of the

cerebrum, forms a surface layer, called the *cortex* ("bark"), about one eighth of an inch thick. This *gray layer is deeply folded*, the folds, or *convolutions*, being separated by deep furrows, some of them an inch deep (see Fig. 158). Thus the area of the surface layer is increased to several times what it would be if smooth. The highest functions of the brain take place in the gray layer. The larger part of the cerebrum consists of the white matter which is within the gray matter. It consists of *fibers which connect the cells in the gray matter with each other* and with important interior ganglia at the base of the cerebrum (Figs. 150, 151, 158). These ganglia are situated just in front of the cerebellum, and above the medulla, and serve to connect the medulla, cerebellum, and cerebrum with each other.

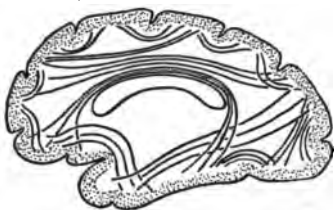


FIG. 150.—ASSOCIATION FIBERS.
(Jegi.)

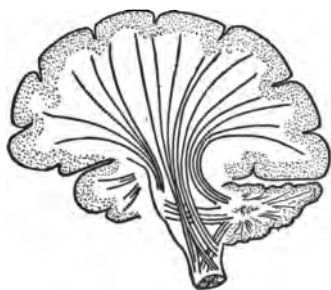


FIG. 151.—SENSORY AND MOTOR
FIBERS. (Jegi.)

The cerebrum comprises nearly seven eighths of the weight of the brain. A deep fissure divides it into the right and left cerebral hemispheres. A band of white matter connects the hemispheres (see Fig. 158). There are several cavities in the interior of the brain filled with the same kind of lymphlike fluid that surrounds it. Two of them are shown in Figure 158.

Spinal and Cranial Nerves.—The nerves from the spinal cord go out through notches between the vertebræ in *thirty-one pairs*, called the *spinal nerves* (Fig. 147).

Since there are only twenty-four vertebræ, some of the spinal nerves go out through holes in the sacrum. The

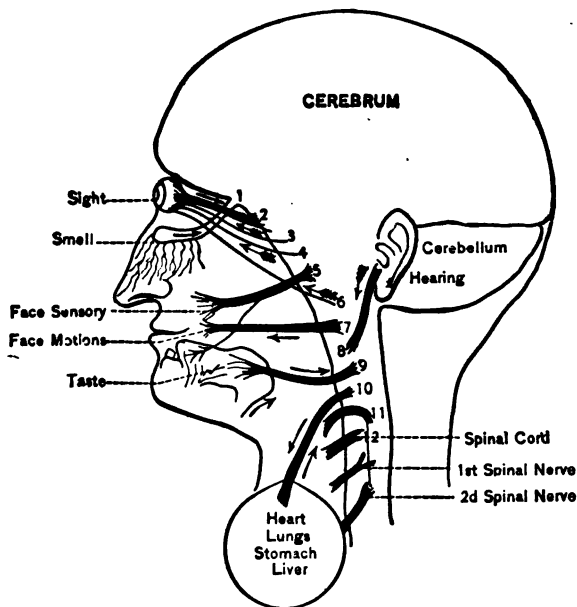


FIG. 152.—DIAGRAM OF THE TWELVE CRANIAL NERVES.

cranial nerves leave the brain through holes in the cranium, or skull. There are *twelve pairs* of them (see Fig. 152). The tenth pair is shown in colored Figure 16.

Functions of the Cerebrum.—

The cerebrum is the seat of *consciousness* and thought, and of all activity controlled by the

will. It also *presides over the work of the lower nerve centers* in the spinal cord, medulla, and cerebellum.

It receives sensory messages from all parts of the skin and through the special senses. It sends out motor messages to all the voluntary muscles, and more indirectly to the involuntary muscles. The cerebral fibers are of three kinds: *sensory*, *associational*, and *motor* (Figs. 150, 151). It is estimated that the cerebrum alone contains 9,200,000,000 cells.

Parts of the Cerebrum that receive Sensory Messages.—

It was discovered a few years ago that certain parts of the brain have definite duties to perform. The nerve fibers

that come from the eyes lead to the lower back part of the cerebrum (see Fig. 154). Thus, although the eyes are in front, we see with the back part of our heads. If you fall and strike upon the back part of the head, you may "see stars," although there are no stars to see. Disease in this part of the brain may result in blindness, though the eyes are still sound. The impressions from the ears in hearing are received just above the ears in the convolutions at the temples. Smells are perceived with the base of the cerebrum toward the front.

Parts of the Cerebrum that send Motor Messages.—The top part of the cerebrum

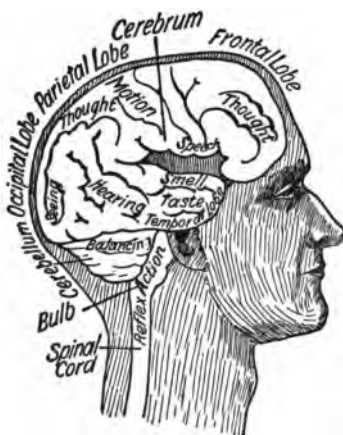


FIG. 153. — THE LOBES OF THE RIGHT SIDE OF BRAIN and their functions. (Jegi.)

The speech center is true only for left-handed persons. Medulla is marked "Bulb."

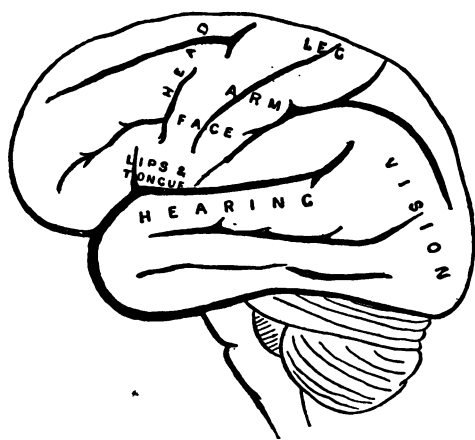


FIG. 154. — MOTOR AND SENSORY AREAS OF LEFT HEMISPHERE. Speech center marked "Lips."

sends out the motor messages. The particular part that controls the arms, legs, trunk, etc., have been mapped out (see Fig. 154). It was noticed by a surgeon that a certain child with epilepsy always had a twitching of the thumb before an attack came on. A small portion of the skull over the

center that controls the thumb was lifted up, and a small tumor was found. This was removed and the skull closed, and the child had no more attacks of the disease. The speech center is in the lower front part of the motor area on the left side (Fig. 153). A blow upon that part of the head may cause a blood clot there, and until the clot is removed by a surgeon or by natural healing, the person is without the power to speak. Since the

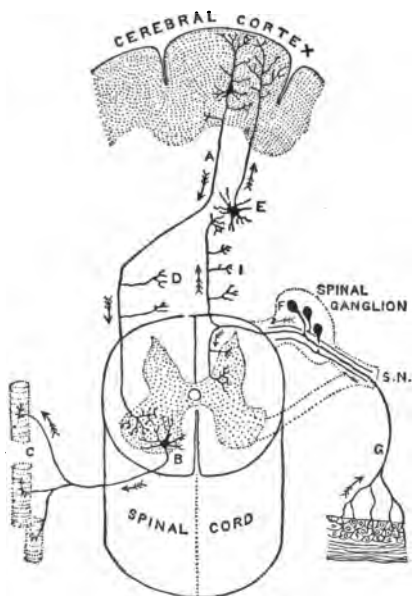


FIG. 155. — PATH OF NERVE CURRENT in voluntary act; arrows show its direction, as follows:

Skin (G), cord, brain, cord, muscle (C). Why can a fowl jump after its head is cut off? Can it breathe?

sensory center for hearing is uninjured, he can understand what is said to him; and since the motor center for the hand is unhurt, he can converse with others by writing his replies.

Relation of the Cerebrum to the Lower Centers. — The ganglia of the lower animals control their simple activities; but the more complex nervous system of man is needed to regulate his varied activities of mind and body. As you learned, these activities are of

several kinds, — reflex, automatic, coördinate, and voluntary. A manufactory has more complex work than a shop. A man with a shop may enlarge it into a factory and leave trained assistants in charge of the different shops, keeping only the general management for himself.

If he should cease to control his assistants entirely, the work of the factory would soon be in disorder. If the manager should try to direct everything, he would become exhausted. So the cerebrum, the seat of the will and the reason, leaves the centers in the spinal cord, medulla, and cerebellum to do most of the work. If the mind wishes the hand to move and grasp the hand of a friend, the motor center in the cerebrum sends a message to the cerebellum; and if the cerebellum has been well trained, the act is accurately performed (Fig. 155).

A more perfect wisdom than that of the mind is in the lower nerve centers. The reason and the will control the lower centers through the cerebrum, but the control is very limited. It is well that this is so, not only for the relief of the cerebrum, but for the safety of the body. Can you change the rate of the heart beat by the exercise of the will? Can you blush at will, or prevent the flushing of the capillaries when you are embarrassed, or when you go close to a hot fire? It is impossible for a person to commit suicide by holding the breath. What change in the blood would soon force a breath to be taken? Repeat the two examples of reflex action triumphing over the will which were given in a preceding paragraph.

THOUGHT QUESTIONS. — Clothing at Neck and Waist. The neck is very [flexible or inflexible?]. It is healthier [with or without?] covering. Stiff or high neck clothing [destroys or preserves?] its beautiful curves, and makes the neck [skinny or full?] and makes one [more or less?] apt to take cold. How may clothing cause backache? (p. 201.)

The most flexible portion of the trunk is the ——. I find by measuring with a tape line, that the circumference of my waist is — inches more with the lungs expanded than when they are contracted. This is called waist expansion. My waist expansion is — inches. If I have my clothing cut to fit the larger waist measure, and support it by the waist, its weight will cause it to slip when the waist contracts in breathing. If cut to fit the smaller waist measure, the — cannot

— and my breathing will be —. The [shoulder or waist?] is made mostly of tough bone and muscle. It contains no delicate vital organs ; it does not expand or contract ; it is horizontal, while the — is vertical. Therefore the — is better for a support to the clothing than the —. The seven vital organs at the waist are the st—, l—, sp—, two k—, p—, and a portion of the large —.

The ganglionic or sympathetic portion of the nervous system controls the viscera (*vis'sē-ra*), or internal organs. The nerves that go to the viscera branch off from the spinal nerves not far from the spinal column, and enter a row of ganglia on each side of the spine (see Fig. 156). Each ganglion is connected by nerves with the one above and below it, so that they appear like two knotted cords suspended on each side of the spinal column and tied together below ; for both chains of ganglia end in the same ganglion in the pelvis. Some of the fibers from the spinal cord pass through these ganglia on their way to the viscera. The spinal cord and brain taken together are sometimes called the *cerebro-spinal* system. The fibers which go through the double chain of ganglia are sometimes called the *ganglionic* or *sympathetic* system. But the division is largely artificial.

Why these Nerves are called the Sympathetic System. — These nerves after leaving the double chain of ganglia form many intricate networks of ganglia and fibers. Each network is called a *plexus* (Fig. 156). The largest of the plexuses is just back of the stomach, and is called the *solar plexus*. A blow upon the stomach may paralyze this plexus and cause sudden death. *The plexuses and fibers connect the viscera so perfectly that one organ cannot suffer without the others suffering or sympathizing with it.* An overloaded stomach causes the heart to beat faster and send it more blood ; a loss of appetite usually accompanies illness and allows the stomach to rest. This sympathy is

necessary, for if one organ is diseased, the others do not continue to work and tax the strength of the ailing organ. For an instance of organs acting in sympathy during a time of increased activity, refer to page 184.

How the Sympathetic and Cerebro-spinal Nerves Differ. — The visceral nerves (1) contain mostly *gray fibers*; (2) pass *through ganglia* after leaving the spinal cord; (3) control the *unconscious* activities of the body; (4) pass to organs which contain slow-acting *involuntary muscles*; (5) transmit impulses *slowly* (about twenty feet per second).

The cerebro-spinal nerves (1) contain only white fibers; (2) do not pass through ganglia after leaving brain and spinal cord; (3) control the conscious activities of the body; (4) pass chiefly to sense organs and quick-acting voluntary muscles;

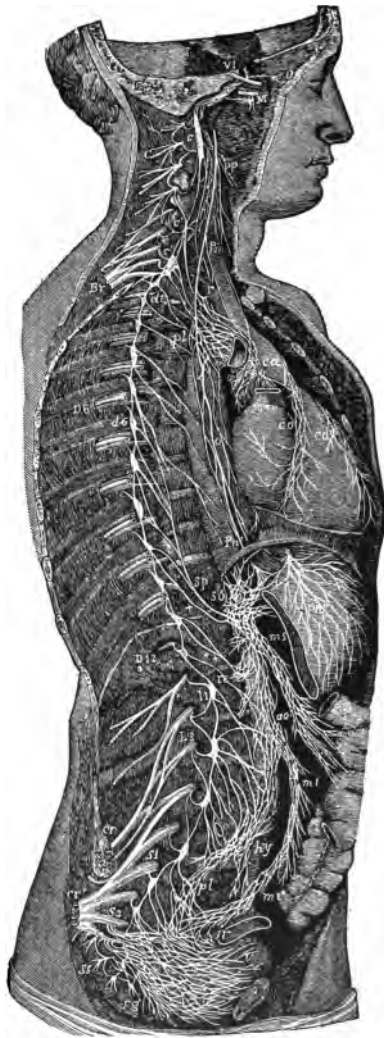


FIG. 156. — THE SYMPATHETIC, OR GANGLIONIC SYSTEM, showing the row of ganglia connected with the spinal nerves of the right side, the plexus at heart, at stomach (solar), and intestine.

(5) transmit impulses at the rate of about one hundred feet per second.

How the Sympathetic System automatically cares for the Body.—The pleasant taste of food causes a reflex stimulation of the salivary glands and the saliva is deposited to begin digestion. When the food goes into the stomach and intestines, their muscular walls are automatically stimulated to contract, and peristalsis begins and the gland cells of those organs form the needful digestive fluids. The digested food passes into the blood vessels, and the beating of the heart and the size of the blood vessels are regulated through certain ganglionic nerves (the vaso-mo'tors) that the food may be properly distributed to the tissues. If the body becomes too warm, the same set of nerves takes less stimulus to the muscles in the walls of the arteries near the surface. The skin becomes red and heat escapes into the air from the warm blood. At the same time, the cells lining the sweat glands are stimulated to increased secretion. If the body becomes too cold, the skin becomes pale and dry, and the heat of the body is economized. At a flash of bright light, the pupils of the eyes slowly become smaller, for the muscles of the iris are involuntary and are under the control of ganglionic nerves.

Usually the ganglionic nerves *care for the vital organs without consulting the mind, but sometimes complaints and warnings have to be sent to the cerebrum.* A person may eat so imprudently that the food tube is unable to do its work. *Colic and cramps and vomiting* may bring relief. If a boy runs so long as to endanger his body, a *pain in the heart* warns him to stop. "*Heartburn*" has no connection with the heart; it is caused by the stomach, and is a warning against eating too much or eating indigestible things next time. It is called heartburn either because

many people think the heart is where the stomach is (see Fig. 94), or because, although not refined enough to keep from eating voraciously, they think themselves too refined to refer to the digestive organs. *Backache* in women is usually caused by the abdominal organs being pushed downward by a tight corset or other clothing suspended from the waist. This causes the sympathetic ganglia to pull upon their attachments at the spine, and backache results.

The mind is only notified of important disorders in the viscera, and any complaint from them should be promptly heeded. On the other hand, unusually strong activity of the brain may affect this system of nerves. Examples: embarrassment causes blushing; the face becomes pale with fear; sadness interferes with digestion and may take away the appetite.

THOUGHT QUESTIONS. — **The Body is wisely Made.** 1. Name four provisions for repair of accidental or unusual injuries to the body (pp. 24, 48, 92). 2. State four facts in anatomy showing provisions for protection (pp. 16, 42, 255). 3. State four similar facts in physiology (pp. 67, 91, 117). 4. Name four provisions for convenience in use (pp. 50, 60, 240). 5. Name four devices used in machinery, examples of which occur in the body (pp. 81, 140, also Fig. 169). 6. Name three devices of architecture found in the body (Figs. 37, 43, 57).

HYGIENE OF THE NERVOUS SYSTEM

Source of Nerve Strength. — The health of the nerves depends upon a free supply of pure, nutritious blood. Nearly one fifth of the blood goes to the brain. Two of the larger arteries that take blood to the brain (the carotid arteries) are shown on Plate XIII. It is clear that the brain cannot give out energy until it has first received it; the blood supplies energy to the brain. A rested cell is full of nourishment; a tired cell is shriveled (see Fig. 157).

Sleep.— During waking hours energy is used up faster than it is stored in the cells, and the tissues are worn out faster than new cells are formed to repair them. During sleep the opposite is true; repair is more rapid than waste. During sleep the muscles are strengthened, the breathing is less, the heart beats more slowly, less heat is produced, digestion is slower, less blood goes to the brain; but above all, the nervous system has an opportunity to recuperate from the constant activity of waking hours. The eye and the ear are rested by darkness and silence. Sleep at night

is more refreshing than sleep in the daytime. Why is it necessary to be more warmly protected by clothing or bed covering when asleep than when awake?

Practical Suggestions.—

Sleep is deepest during the second hour after going to sleep, and a greater shock is given to the nervous system by waking a sleeper during that hour than at another time. An alarm clock is a very unhealthful device.

Infants sleep most of the time, and it is injurious to

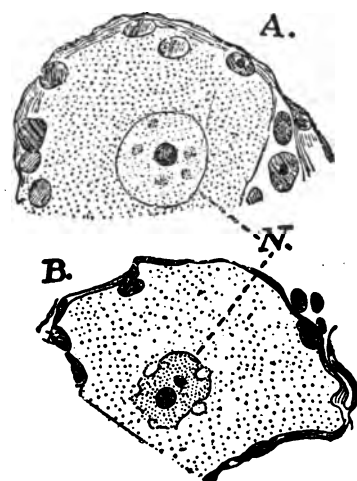


FIG. 157.—EFFECTS OF FATIGUE ON NERVE CELLS.

A, resting cell, *B*, fatigued cell, with its body and nucleus shrunken.

awaken them. Adults usually require about eight hours of sleep. There is a risk in going to sleep in a warm room, for the bed covering which is comfortable then may not be enough to prevent taking cold when the fire goes out. Sleep comes more promptly to one who goes to bed at the same hour each night. The muscles are re-

laxed in sleep, and to relax them perfectly upon lying down, tends to bring sleep. One who is sleepless, usually finds that he is holding the head stiff on the shoulders, the teeth clinched, and the muscles contracted, even though he is lying down. Excitement and worry during the day, but especially just before retiring, tend to produce sleeplessness.

Preparing for Severe Mental Effort. — Two students were studying hard one night for an examination to be next day. One of them went to bed a little earlier than usual as a part of his preparation for the work. The other sat up two hours later than usual. The first student made a high grade; the second hardly passed. To rest the brain by plenty of sound sleep, and go to work with the brain cells fresh and the blood pure, is a far better preparation for an examination than to attempt to cram a few more facts into the head and shorten the hours of sleep. Loss of sleep is a serious matter in youth when the cells are growing.

Resting the Mind while Awake. — It is not necessary to go to sleep to rest the mind. Change of occupation and change of the subject of thought rest the mind *by resting the tired nerve cells and bringing new cells into action.* Pupils can become rested more quickly by rising in their places and taking gymnastic exercises than by simply closing their books and sitting still. Enjoyable recreation, and doing things simply because we like to do them, are very necessary to the health of the nervous system and to success in life. *There are times when change from mental to physical occupation cannot bring rest; the will power is tired out, and only ceasing from all activity will refresh us.*

Habits. — Our habits of doing and thinking and feeling really constitute our characters. This shows the importance of right habits. By gradually changing our habits we can

strengthen our characters and form them somewhat as we wish. When a muscle contracts in a certain way, this act makes it easier for the muscle to contract in that way the next time; thus great muscular strength may be developed. *Whenever a nerve cell acts in a certain way, it is easier for it to act in the same way the next time.*

How Habits are Changed. — We cannot all at once change our characters or habits of thinking and feeling by mere power of will. New habits must be gradually formed. If the cells used in a certain deed or thought are repeatedly active, *it is believed that the circulation around these cells will be increased and they will grow larger, and the branches that connect them with other cells will develop more and more.* Thus a good habit becomes fixed, and thus a bad habit is formed. To overcome the bad habit, *these cells must be weakened by disuse.* The branches that make the undesirable connections with the cells must be allowed to draw back and the blood supply to become less. The longer the cells are kept inactive, the less likely the habit will be to return; but a slight danger of its return may exist all during life. *Habits that are formed in youth while the nervous system is developing are the hardest to break.* It is difficult to break a habit, whether good or bad, that continues until one is twenty-five or thirty years of age.

Education of the Nervous System. — There is a natural tendency to fall into habits, for the body works easier in that way. There is no reason for always putting on one shoe before the other, yet many persons always put on the same shoe first. It is the duty of every person, and especially of young people whose habits are so easily formed, to practice doing useful things well, such as writing, speaking, standing, walking, until the habit of doing

them well becomes reflex action and the cerebrum can intrust the action to the lower nerve centers. The chief purpose of education is to train children into desirable habits of thinking and doing, so that when they are grown they will have good habits as good friends to help them. We cannot get entirely rid of our habits, because we cannot get

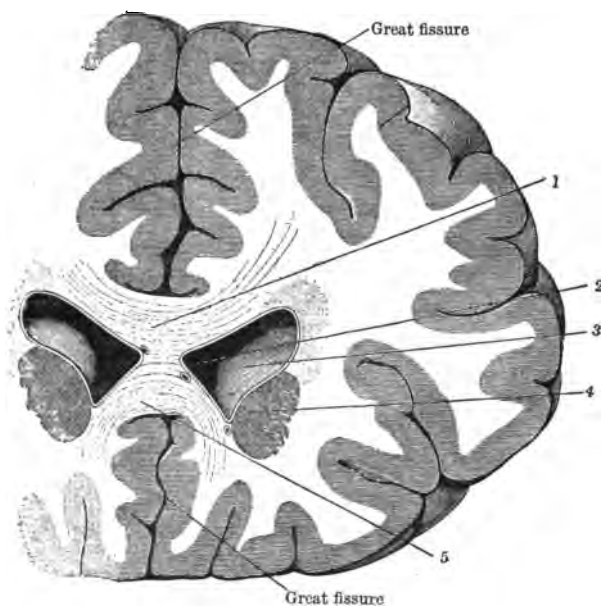


FIG. 158. — SECTION ACROSS CEREBRUM, showing thickness of gray matter, depth of convolutions, band of white fibers (1, 5) connecting the two hemispheres; ventricles (2) or cavities in brain.

rid of our brains. Self-control, neatness in dress, slow eating, consideration for the feelings of others, keeping the temper, mental and physical industry, are a few things that may become habitual and help to form the true lady or gentleman, and make life successful and happy. It is usually easy to tell if a person, as we say, "has had good breeding," that is, has grown up among people of refined

habits. But no one can set limits to the power of thought and of confidence in one's self to change nerve structure.

Healthy fatigue is caused by the accumulation of waste products resulting from the activities of the nerves, muscles, and other organs. Their presence in the tissues affects the nerves. We feel rested when these wastes are removed; we are strong again when the tissues are supplied with fresh food and oxygen. Work causes the accumulation of carbon dioxide, which is nature's narcotic. The drowsy feeling that ensues is more pleasant than the drowsy feeling from alcohol, or opium.

Fatigue without work occurs with people who are idle and exert no energy, yet who eat immoderately, and perhaps live in unventilated houses. The oxidation in their cells is not complete, and poisonous products of the incomplete burning result. These are taken by the blood to the nerves and brain, and give a tired feeling as effectually as does hard work. Persons who do no muscular work often have imperfect digestion; the food ferments in the food tube and forms poisons which increase the tired feeling. Persons who never work, yet who never have any energy and are said to have been "born tired," are suffering from this kind of fatigue. They are usually irritable, while persons who are fatigued by useful labor are likely to be dull and drowsy.

Pains and Aches. — Pain is the warning to the mind of an injury or a threatened injury to a nerve. As the nerves are found everywhere except in the epidermis, hair, and nails, the body is thoroughly protected by the nerves. A pain is short and from one spot; a pain continued for a long time, and coming from a larger area, is called an ache. Pains and aches may result from: (1) *cutting* or tearing a nerve; (2) *pressing* upon a nerve or stretching it; (3) depriving a nerve of *nourishment*; (4) allowing *poison* to reach the

nerves. When the injury to the nerve is located outside of the skull, the mind refers the pain to the injured spot. When we were infants we learned to refer hurts to the injured place on the body. All our lives since then, when the pain comes along any certain nerve, we have thought of the cause of the pain as being at the end of that nerve. Hence for many years after an arm is cut off irritation at the end of the stump causes an imaginary finger to itch. This shows that the itching never was in the finger, but was in the brain, even before the finger was cut off. Pain in the part of the nervous system situated within the skull usually lasts for some time, and is called a **headache**. Headaches may result from either of the four causes of pain mentioned above except the first (why not the first?), and they will be studied in the same order.

Headaches from excessive blood pressure in the brain are caused by too much blood in the brain. During such headaches the head may seem to throb with each beat of the heart. Excitement or momentary anger may bring on this form of headache by increasing the rate and strength of the heart beat. Cold feet may cause it, since the contracted capillaries of the feet prevent the usual amount of blood from flowing through the legs; and the blood, which cannot go downward, follows the arteries that lead up to the head. If a meal is omitted, the blood which would have gone to the digestive organs to aid them in their task may accumulate in the head. If one's nerves are accustomed to coffee, tea, or wine taken at meals, leaving off a meal is more likely to cause a headache.

Headaches from Imperfect Nutrition.—If the blood in the body is thin or lacking in quantity, that is, if the person is *anemic*, headaches are frequent. (In what part of the head? See Fig. 159.) This condition of the blood

(called *a-ne'mi-a*) can be cured by drinking plenty of water and by a more active life. An active life in the open air causes deep breathing and gives a good appetite and good digestion. The air and water and assimilated food soon make plenty of pure, rich blood, and the headaches cease. What is the color of an anemic person's skin? What does this show to be lacking in the blood?

The brain may be imperfectly nourished because of *overwork*. The headache is simply the cry of a hungry nerve

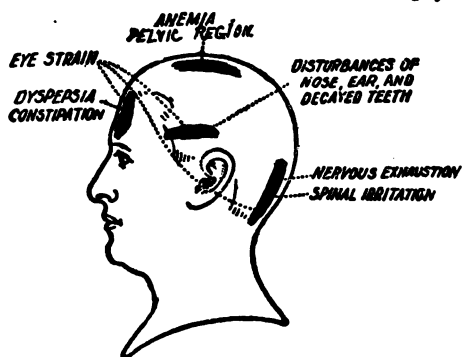


FIG. 159. — THE SITUATION OF HEADACHES with reference to their causes.

for food, or for the removal of carbon dioxide and other fatigue poisons (see next topic). Overworked nerves result from excessive mental labor, insufficient sleep, worry, long-continued anger, or other emotional excitement. Eye strain, a form

of overwork that causes many headaches, results from using the eyes upon fine work, or in a poor light, or in a glaring light, or with light coming from below the level of the eyes. The nerves of the eye may also be exhausted from straining caused by defects in the eye. Where would this headache be? (Fig. 159.) Eye strain may also exhaust the optic tract in the cerebrum. Where would such a headache be? (Fig. 159.)

Headaches from Poisons and Impure Blood. — Impurities and poisons which cause headaches, may enter the body from without, or they may be formed in the body. Examples of *poisons from without* are,—lead from lead water pipes, mercury in medicines, alcoholic drinks, car-

bon dioxid in unventilated rooms, especially schoolrooms under the control of careless teachers. Coffee, tea, and tobacco may cause headaches; sometimes by their narcotic or deadening effect they stop headaches.

Among *poisons formed within the body* and causing headaches are carbon dioxid and other fatigue poisons. Chronic nasal catarrh causes headaches because of the impurities thrown into the blood by the breaking down of the inflamed tissues in the nasal passages. Food may remain for some hours undigested in the digestive organs, either because it is excessive, indigestible, or taken when there is no appetite, or when the body is much fatigued. The *undigested food decomposes* in the warm, moist food tube, and is changed into poisons instead of nutritious substances. Strange to say, this does not so often cause stomach ache as headache. The reason for this is that the brain receives more blood in proportion to its size than any other portion of the body; the poison circulating through the brain often causes a severe and painful trouble called "sick headache."

Prevention and Cure of Headaches. — Headaches, like all other pains, should be a source of benefit in that they show us ways of living to avoid in the future. Many persons, however, not only derive no profit from a headache, but by unwise efforts to cure the pain, bring permanent injury to themselves in addition to the suffering of the headache.

Bromides, opium, and other *poisons* deaden and weaken the nervous system while preventing the pressure or poison that is causing the headache from being felt. *Headache powders*, phenacetin, acetanilid, antikamnia, and other vile poisons made from coal tar, shock and weaken the heart and reduce the vital activities so that the headache is no longer felt. In consequence of shocks from

repeated doses of such drugs, the heart will not work so well, and may give way some time in the future when an effort or strain makes unusual demands upon it. The liver and kidneys have to destroy and remove the drugs.

A commotion at midnight in a hotel once disturbed the writer. He found that a young lady in the room above had been taking acetanelid for sick headache; her body had turned almost blue from the blood flow ceasing, and efforts were being made to save her life. She recovered, but one week afterward, when another sick headache came on from overeating or exhaustion, she at once took the same drug again. Many people are foolish enough to injure their bodies and risk death rather than suffer pain, or avoid pain by prudent living. *Sick headaches are foretold* by a dull feeling, sleepiness after eating, a coated tongue, and constipation. It would be better to remove the undigested, spoiled food from the stomach by an emetic or otherwise than to take a narcotic. But the most rational way is, at the first indication of trouble, to abstain from eating, or use a fruit diet for twenty-four hours, and drink water freely. This will enable the body to dispose of the excess of waste matter.

THOUGHT QUESTIONS ON HEADACHES. — Write 2, 3, or 4 after the following causes of headaches to show with which of the causes on page 206 each belongs: Headache from standing a long written examination. Headache from violent running. Headache of a drunkard recovering from a "spree." Headache from idle living and neglect of exercise. Headache of a boy who hung with his head downward while acting on a horizontal bar. Why is it possible to sleep off a headache? What are the three causes of headache over the eyes? (See Fig. 159.) What causes headache above the ears? In the top of the head? In the temples? In the back of the head? What is the cure for anemic headaches? (p. 100.) How may the drunkard's headache be avoided? How should headaches from overwork be avoided? Headaches from eye strain may be avoided by the use of glasses or by sparing the eyes.

Many **drugs** act upon the body by stimulating the nervous system. They are used with the view of restoring the balance when the organs are not working in harmony. A sick person should ascertain whether or not the trouble is caused by wrong habits of living. This is as important as to employ a physician. It is more necessary to change wrong habits than it is to take drugs.

Applying Hygiene systematically.—The cause of ill health should be sought with system and thoroughness, applying the tests in rotation to every function of the body: *Lungs*. Is the air habitually breathed fresh and free from dust? Is the body held up, and is the chest or waist cramped by clothing? *Muscles*. Is enough physical exertion made to cause deep breaths to be drawn? *Food*. Is it simple, digestible, and eaten properly? *Drink*. Is the water pure? *Cleanliness, Work and Rest, Clothing, Ventilation, and Mental State* may be inquired into until the source of trouble is found and the cause of ill health removed. To give drugs and leave the cause of ill health untouched, is to fail. There are signs of coming weakness or illness which, if heeded and the ways of living improved, will usually prevent illness. Among these signs are headaches, paleness, sensitiveness to cold, heavy feeling or pain after meals, constipation. Huxley says that young people should so learn physiology and so understand their bodies that they will *heed the first signs of nature's displeasure, and not wait for a box on the ears.*

Nervous Children.—A report on the health of the school children in one of our largest cities contains the startling statement that one third of the children in those schools have some disorder of the nerves. Nervousness (weakened control of the nerves) may show itself by sluggishness of mind, great *irritability of temper*, frequent

spells of the "blues," or by involuntary movements of a jerky or fidgety kind. Sound development of city children's nerves is hindered because of the constant noise in cities both day and night; by shortening of the hours of sleep; by excessive use of sugar for food; by living much among people with no chance to be alone and let the nerves rest, and among boys by the use of cigarettes.

Need of Freedom for Growing Children.—No farmer thinks of confining or of working a colt until it is nearly grown and its body has reached a certain degree of toughness. Dr. Seaver says that free activity and opportunity for gratifying the instinct to play is almost as necessary for growing girls and boys as it is for a colt. Confinement for too many hours in school, or staying closely in the house and reading books, may stunt and weaken their bodies for life. Book work, although useful and almost as indispensable as health for success in life, is not a natural occupation even for adult man. It is unknown among tribes that lead simple lives. The *strain upon the eyes*, the *flattening of the chest*, the *breathing of indoor air*, and the *restraint upon the muscles* make the study of books a risk to the health of children if injury is not carefully guarded against. So slight is the regard for health by parents and teachers that scholarship is more often the first aim. The recent plan in progressive schools of having physical exercises in the midst of each division of the day's session is not likely to be given up. The reason stated for retaining it is not in the improved bodies that doubtless result, but because the relief from mental strain enables the pupils to study better after the physical exercise is over. Statistics show that the most successful men, and even the best scholars in the world to-day, do not come from schools where much book work in and out of

school is required for ten months in the year, but from localities where the schools are open not longer than six or eight months in the year, and the chance for stuffing the mind is limited. In such districts the pupils often walk miles to school, a custom that would be considered beyond the power of city children.

How to prevent Confinement and Study from injuring Children.—This is an important question, for upon its answer depends whether children shall grow up weak and nervous, or successful and efficient workers. (1) *Ventilation* is of first importance. The air of many homes and schoolrooms is very impure. (2) *The time devoted to work* should not be very long, especially in the lower grades. (3) *The work should be diversified*; not only books, but natural objects and the outdoor world should be studied. The pupils should be taught how to live instead of being trained into unhealthy habits of living. Wisdom, or the knowledge how to live, is as important as learning, or the knowledge of books. What is learned in books may be forgotten in a few years, but the knowledge how to live is useful for the rest of life. A child that is devoted to books so as to study continually is an abnormal child. (4) The teacher and parent should see that *the habitual poise* of the child is favorable to health and activity, and that the attitude assumed does not interfere with breathing and blood flow. A sensible child will heartily cooperate in this. Study Figs. 49, 59, 61. (5) The children should be *encouraged to play*, and every possible opportunity should be given to gratify the play instinct. (6) *Physical exercise* should be provided at short intervals, especially *stretching exercises* and *movements that straighten the spine and hips and elevate the chest*. Running games at recess are of the greatest value. Dr. Seaver says that

children under nine years of age should be given physical movements in school for five minutes in every half hour ; from nine to thirteen years, ten minutes every hour ; above

thirteen years of age, fifteen or twenty minutes in the middle of both morning and afternoon sessions.



FIG. 160.—FOUR CELLS from the brain of a man who died of alcoholic insanity.

Compare with A, Fig. 142. A drunkard with nerve cells partly destroyed will hardly have will power to break a habit.

The effect of alcohol upon the nerves is in rare cases to bring on a painful disease called neuritis, or inflammation of the nerves. (The ending “itis” means an inflammation. What is tonsillitis?)

Alcohol seems to attack the nerve centers, beginning with the cerebrum, the highest, and proceeding toward the lowest. Hence as a man becomes drunk he talks foolishly (cerebrum affected) before he staggers (cerebellum affected), and he finally goes to sleep and breathes very hard (medulla affected) in a drunken stupor. It sometimes happens that the breathing center is completely disabled, and the man dies from the strong poison. For the effect of chronic alcoholism upon the nerve cells, see Fig. 160.

PRACTICAL QUESTIONS.—1. Why does travel often cure a sick person when all else fails? 2. Why is working more healthful than “taking exercise”? (p. 62.) 3. Is it better for children to play or to take exercise? 4. Why can one walk and carry on a conversation at the same time? (p. 196.) 5. How does indigestion cause a headache? (p. 209.) 6. Does perfectly comfortable clothing from head to foot help to make one at ease in company? Does uncomfortable clothing tend to make one awkward? 7. Why is it as important to have the shoes and clothes perfectly comfortable when going out as when staying at home? 8. When one's finger is cut, where is the

pain? (p. 207.) 9. Does the girl who frets over washing the dishes, working with an unwilling mind, and the boy who, while he is sawing wood, is wishing to go to a baseball game, do their work with more or less fatigue than if they worked cheerfully and willingly? Why? 10. In what two ways may opening a window when a student is becoming dull and drowsy at his books enable him to wake up and study with ease? (p. 221.) 11. What kinds of cells shrivel like a baked apple when they become fatigued? (Fig. 157.) 12. A nerve or nerve fiber can hardly become tired or fatigued, for the nerve cell supplies the energy. What do we mean when we say the nerves are worn out? (Fig. 157.) 13. Why do you throw cold water upon a fainting person? 14. Why does constant, moderate drinking undermine the health more than occasional intoxication? 15. Why does stoppage of the circulation cause one to faint? (See Chap. VI.) 16. Why is grazing the skin often more painful than cutting it? (Fig. 22.) 17. Do alcohol and other narcotics first tear down the tissue of the higher or lower nerve centers? 18. Why do the lower animals always act upon sudden impulse? What part of the brain enables man to retain sensations and not act upon them until later? 19. Does "nervousness" more clearly indicate a bright mind or a high temper? 20. What is the effect of a cold bath upon the nerves?¹ (Chap. II.)

REVIEW QUESTIONS (STIMULANTS AND NARCOTICS).—What effect does alcohol have upon one-celled animals like the ameba? State a fact which shows that alcohol used as a beverage weakens the vitality of the cells and lessens their power to repair the tissues of the body (p. 48). How does alcohol affect the capillaries of the skin? The mucous membrane of the stomach? Does alcohol strengthen the heart? Is it a heart stimulant? How does alcohol affect lung tissue? Is alcohol a food? What were the facts shown by Atwater's experiments? What was his conclusion? What facts were proven by Beebe? What is the probable explanation of them? Were Atwater's experiments with abstainers? Were Beebe's? Why do experiments upon total abstainers give slightly different results from experiments upon drinkers? What disease of the nerves is sometimes caused by alcohol? In what order are the nerve centers disabled by alcohol? State the two reasons why cigarettes are far more destructive to health than cigars.

¹ A shower bath is best to stimulate the nerves in the skin. If a bath room is not at hand, it may be taken by tacking one yard of oil cloth upon a wooden frame and using it for a mat upon which the bather stands and pours water upon himself with a pitcher or flower sprinkler. A bath mat and sponge are preferable to a tub, as only fresh water reaches the body. An air bath of half an hour with vigorous rubbing is good for the nerves.

Definitions: Stimulant, Narcotic, Poison. — *A stimulant is anything that causes the body to do more work without giving extra strength with which to do it.*

A narcotic is anything that deadens or dulls the nervous system. It comes from a word meaning "to benumb."

Poisons are active substances which, taken in quantities as man takes food, destroy life; in smaller quantities they injure the body and may destroy life. Alcohol is a poison. Wine, beer, whisky, contain varying quantities of it.

The Narcotic and Stimulant Effects of Poisons. — *Examples of poisons are alcohol, nicotin, opium, arsenic, strychnin. Poisons excite the body when taken in small doses, while in large doses they produce paralysis and death. The exciting or stimulating effect is due to derangement of the functions or to the efforts of the cells to free the body of the destructive substance. The narcotic effect is due to the poison having so benumbed the nerves and injured the cells that their activities cease, or become less for a time. You readily see how the same poison can be both a stimulant and a narcotic: the stimulating effect always comes first, followed by the stupefying effect. If the dose is very small, the stimulating effect will last longer; if it is large, the narcotic effect is greater and felt more quickly.*

Reaction. — *This is the depressed and exhausted condition that comes on after a period of unnatural activity. It follows the exciting effects of even those stimulants which are not narcotics. The exhaustion that follows the first exciting effect of narcotics helps the narcotic in further depressing the activity of the body.*

Natural Stimulants. — *If there were nothing to arouse activity, life would be impossible. A cold wind is a stimulant, since it arouses energy but gives none. The activity*

aroused by a cold wind is just enough to help the body withstand the cold; artificial stimulants cause an expenditure having no relation to the needs of the body. Hence there is a great waste of energy. Feelings may stimulate, as love for his family may stimulate, a man to labor. The desire for knowledge may stimulate a boy to study. Hunger may stimulate a man to eat. Hunger is a natural stimulant, and is not likely to make him eat to excess; tea, coffee, pepper, etc., arouse a false appetite. These things are used chiefly for their stimulant effect, since they contain little or no nourishment. The rest of this chapter treats of artificial stimulants. *Such stimulants always cause an unregulated and unhealthy action, and are always followed by reaction.*

How Much Strength is stored in the Body? — Dr. Tanner of Minnesota believed that most people eat too much. *Another physician said that no human being could go forty days without food.* Dr. Tanner made the experiment. He lost thirty-six pounds in weight, but he weighed 121½ pounds and had considerable strength at the end of the forty days. The first thing he ate at the close of his fast was the juice of a ripe watermelon.

Once some miners were shut in by the caving of a part of a mine. But, unlike the case just described, *they were without water as well as food.* When, by digging, the rescuers reached them seven days after, several were still found alive, although most of them had died. The miners, no doubt, had nourishment in their bodies for some weeks more of life, but the body lacked water to dissolve it and bring it within the reach of the cells most needing it.

A Stupendous Fact. — These incidents show how wisely the body is made, and prove that the cells store up nourishment for weeks ahead. *The large amount of nourishment*

stored in the human body is one of the most striking and important facts with which the science of physiology has to deal, and it should be borne in mind, or we may make great mistakes about some very simple matters.

Foolish Rashness. — Did you ever get so tired that you had to give up and stop, however much you would have liked to continue at work or play? *To rest was the wise thing to do.* Because you have now learned from physiology how much energy you have stored up within your frame, you should not in the future be tempted to go on until you almost break down. Probably you know *people who are conceited about their bodies* and say they are "made of cast iron"; that nothing can hurt them. Did you ever know anybody who was conceited about his mind and thought he was very bright? It is just as foolish to be conceited about the body as about the mind.

How a Safeguard may be broken down. — It is a very wise arrangement that, *under ordinary conditions, we cannot get at the surplus energy we have.* Carbon dioxide and other wastes accumulate in the tissues and paralyze the nerves. Fatigue and other feelings compel us to be provident, as it were; yet stimulants and narcotics, by irritating the nerve cells, arouse them and cause us to expend some of this reserve energy. Thus man is enabled to get at this precious store which he should save for emergencies, when he is sick and cannot digest food, or when he is making some mighty effort. This reserve energy may be needed to enable him to pass through some very trying time without breaking down. Did you ever know of a weak, sick person who had eaten very little for weeks, yet was so powerful that it took several strong men to hold him in bed? This sometimes happens in the case of a sick person who is delirious and crazed by pain and by the

poisons formed in the body during illness. But the delirious mania often uses up the little energy left, and costs the person his life.

The only source of energy for man's body is the union of food and oxygen; he must get his energy from the same source that the engine does; and this is from his food, which serves as fuel, and the oxygen which burns it.

Fatigue of Body and Brain. — Suppose you are tired or worked down. The fatigue depresses you and you feel discouraged. What ought you to do? Why, rest, of course, and you will soon feel all right again. This seems very simple, yet some people will not do this way, but will take an alcoholic beverage or tobacco, which will keep them from feeling tired when they are tired. If you have been working hard preparing for examinations, or gathering hay, or in attending to some important business, or have been under the excitement of some pleasure trip, and *feel "blue" and worn out, then bear the result like a man,* or like a true boy or girl, as the case may be. Giving up for a while, or "toughing it out" with the blues, or losing a little time from business, will not hurt you, but will make you strong, while a stimulant will leave you less of a man than before.

Alcohol is used to get strength out of a man, not to put it in. When a person feels that he is all tired out and his nerves are weak and takes a stimulant, it is the same as if, when his horse shows signs of breaking down, he should lash him with a keen whip, or pierce him with a sharp spur, instead of letting him rest. Many a fine horse has been spoiled in a few hours under the sting of the whip, and many a man has been physically ruined for life by overworking, goaded on by alcohol, during one season of business rush.

Mistaking the Source of Energy. — You remember those wonderful little one-celled animals, the amebæ. If poison is brought near, they will try to escape it. Likewise, if a man who has never used either alcohol or tobacco, takes one of them into his body, the cells will try to throw it off. Secretions are poured out by the cells to dilute and weaken the poison, and the derangement of the organs excites the body to some extent. This, with *the dulling effect upon the nerves, keeps the man from noticing fatigue*; so he thinks the narcotic has given him renewed strength. Strychnin is one of the deadliest poisons known, and also one of the most powerful stimulants. If a cat is given strychnin, its nerve tissue becomes so irritable that a loud sound, or merely touching any part of the animal will throw every muscle of its body into a spasm.

Quieting the Nerves. — Some people are coffee toppers and tea toppers. It is a mistake to say these things quiet the nerves. Who is so nervous as the old lady who drinks frequent cups of tea to quiet her nerves? It is the tea that is making her nerves unsteady. Some people unaccustomed to tea will lie awake the greater part of the night wearing out their energies by sleeplessness if they drink only one cup of it. Useful labor, pleasant games, and a contented mind will quiet the nerves without injuring them.

Stimulants have less medicinal effect when given to persons already accustomed to their use. It is easy to understand how a person sitting up with a friend who is dangerously ill will take tea or coffee to keep him wide awake. If he is not in the habit of using them, they will keep him awake more effectively than if his body has become used to such an unnatural intruder. In some emergencies there may possibly be reason in stimulating

the activities, even if reaction and depression must be suffered thereafter. One whose strength has given out because of exposure to severe weather may be temporarily revived by alcohol. *It will not be wise to do so unless it is certain that a warm fire and protection will be reached before the reaction comes.* Much less would be necessary to revive an abstainer than a drunkard. But is it unwise *habitually* to disturb the body with narcotics, such as alcohol or tobacco?

Natural stimulants do not cause depression. The chief natural stimulants are cold air, sunlight, pure air, physical exercise, interest, joy, and other emotions. A deep breath of pure air is a better stimulus than a glass of beer; climbing a hill or sawing a log of wood will make the blood flow faster than will alcohol; a pleasant talk with a friend is a better sedative than a cigar; a cold day will steady the nerves better than an opiate; a trust that a good Power rules over all will drive away worry quicker than cocaine; a cold bath will bring steadier nerves than coffee; a cold wind will give a better appetite than food soured with vinegar or hot with pepper. Natural stimulants do not produce a reaction because they do not excite the body to an injurious degree, nor cause the energies to be consumed beyond the danger point. Persons who go through life under the stimulus of these natural blessings have sound, steady nerves and clear brains. They do not have to take anything to "quiet their nerves."

Artificial Stimulants. — Suppose man wishes to improve on the simple blessings of life. He must stay in the house continually in order to transact much business and make money, or to acquire precious wisdom in musty books. He must curtain off the sunshine for fear it will cause his fineries to fade, must shut out the air and keep

in the dust. He fears a cool draft upon a skin made delicate by a load of clothing or overheated rooms. The motions of his body are confined mostly to his fingers and his tongue as he writes and talks in transacting business; he is too proud to walk or to work with his hands, and thus the circulation throughout his body becomes sluggish. His natural appetite becomes weak, and would regulate the amount of food according to the narrow, one-sided life he is living, but he arouses an artificial one with sour or peppery seasonings, and the half-digested food makes poison for his blood. His nerves become weak, his mind weary, his body tired and depressed.

The Apparent Result. — He adopts the use of poisonous stimulants, for in the effort to rid themselves of the poisons the cells become active, and the awakening of his weakened system gives him the feeling of power and enables him to stick to his work and his unhealthy life. Coffee, tea, tobacco, wine, beer, whisky, form the steps toward ruin. He may feel worn out, but a strong cigar, sending the poisonous fumes of nicotin into his delicate, thin-walled lungs, will so excite his nerves that he feels vigorous, and says, "What nerve strength comes from tobacco!" For *we feel vigorous when we are expending energy very rapidly, even if the store of energy is nearly exhausted.* He feels discouraged and weak, and takes a glass of whisky: this disturbance to the system, with the great amount of energy expended in getting rid of it, makes him think he has had a sudden increase of strength.

Old Friends Forgotten. — He forgets the work that the faithful, industrious stomach has been doing in storing away food in the cells (alcohol is never stored in the cells, but all foods are). He forgets the busy lungs and

the oxygen they have been storing in the blood. He knows nothing of the millions of little cells that have been storing up food in the tissues ready for use.

The Real Result.—The drinker is like the man who has piled up money in a bank and draws it out with checks and says: "What a wonderful thing a check is! How valuable is my check book!" But, if he were to lose the check book, the bank would give him another for nothing. The check, when written, is a sign that money must come out of the bank, and the alcohol, when taken into the body, is a sign that strength must come out of the body in destroying the enemy. No wonder the man has a bad headache the next morning; no wonder his health and character are gradually ruined.

Two Kinds of Thriftlessness.—Did you ever know persons who could not keep any money or property? Dollars seem to burn holes in their pockets. They do not know how to economize when resources are low, but are always getting in debt and borrowing, and mortgaging their crops or their stock or their homes. There are many such people, and there are just as many who cannot store up any of that precious capital consisting of bodily health and strength. If they feel buoyant and strong, they will not economize their strength, but work or go on until they are worn out, and then take tobacco or alcohol to deaden the tired feeling. If a man is weary, it is not to his interest to *feel* rested until he *is* rested. Such feelings are a cheating of nature.

Senator Chauncey M. Depew on the Effects of Tobacco and Alcohol.—It was reported that Mr. Depew had become a believer in tobacco and had bought cigars and smoked with some friends at the Mills Hotel, New York.

This is his reply to a lady who inquired if the report was true:—

“NEW YORK CENTRAL & HUDSON RIVER R.R. Co.
NEW YORK, Jan. 27, 1898.

“OFFICE OF PRESIDENT.

“MISS LUCY PAGE GASTON,

“*Dear Madam*: I am in receipt of your letter of Jan. 20th.

“I did not buy any cigars at the Mills Hotel and have not smoked one for many years. The statement in your slip (herewith returned) about my abandoning the habit is entirely correct.

“Yours very truly,

“CHAUNCEY M. DEPEW.”

The following is the slip referred to, giving his *experience as a smoker*:—

“I used to smoke twenty cigars a day, and continued it until I became worn out. I didn't know what was the matter with me, and the physicians that I applied to did not mention tobacco. I used to go to bed at two o'clock in the morning and wake at five or six. I had no appetite and was a dyspeptic.

“I was in the habit of smoking at my desk and thought that I derived material assistance in my work from it. After a time I found that I couldn't do any work without tobacco. I could not prepare a brief or argument without tobacco, but still I was harassed by feeling that something was amiss, and the result was not up to the mark.

“I also found that I was incapable of doing any great amount of work. My power of concentration was greatly weakened, and I could not think well without a lighted cigar in my mouth. Now it is perfectly clear that without this power of concentration a man is incapable of doing many things. It is this which enables him to attend to various affairs; to drop one absolutely and take up another and give it full attention. One day I bought a cigar and was puffing it with a feeling of pleasure which is only possible to the devotee. I smoked only a few moments, and then took it out of my mouth and looked at it. I said to it: ‘My friend and bosom companion, you have always been dearer to me far than gold. To you I have ever been devoted, yet you are the cause of all my ills. You have played me false. The time has come that we must part.’ I gazed sadly and longingly at the cigar, then threw it into the street. I had been convinced that tobacco was ruining me.

"For three months thereafter I underwent the most awful agony. I never expect to suffer more in this world or the next. I didn't go to any physician or endeavor in any way to palliate my sufferings. Possibly a physician might have given me something to soften the tortures. Neither did I break my vow. I had made up my mind that I must forever abandon tobacco, or I would be ruined by it.

"I have never smoked from that day to this; and, while no one knows better than I the pleasures to be derived from tobacco, I am still well content to forget them, knowing their effect."

The following remarks on *the effects of alcohol* are from a speech by Mr. Depew:—

"Twenty-five years ago I knew every man, woman, and child in Peekskill, and it has been a study with me to mark boys who started in every grade of life with myself to see what has become of them. I was up last fall and began to count them over. It was an instructive exhibit. Some of them became clerks, merchants, manufacturers, lawyers, doctors.

"It is remarkable that every one of those that drank is dead; not one living of my age. Barring a few who were taken off by sickness, every one who proved a wreck and wrecked his family did it from rum and no other cause.

"Of those who were church-going people, who were steady, industrious, and hard-working men, who were frugal and thrifty, every single one of them, without an exception, owns the house in which he lives and has something laid by, the interest on which, with his house, would carry him through many a rainy day."

The use of alcohol is a **great disadvantage in business**. Would you prefer an abstainer or a drinking man for a physician, for the engineer of the train you travel on, for a teacher? The following notices show the effect of drinking alcohol upon a railway man's success:—

"CANADIAN PACIFIC RAILWAY COMPANY.

"In the interests of safety and efficiency, the use of intoxicants while on duty is absolutely prohibited. No instance of intoxication on duty will ever be overlooked, but will be followed by immediate dismissal. The habitual use of intoxicating liquors will be considered sufficient cause for dismissal, and preference will in every case be given to those who abstain from their use.

"J. W. LEONARD, General Superintendent."

"NEW YORK CENTRAL & HUDSON RIVER R.R. Co.

"The use of intoxicating drink on the road or about the premises of the corporation is strictly forbidden. No one will be employed, or continued in employment, who is known to be in the habit of drinking intoxicating liquor.

"E. VAN ETTEN, *General Superintendent.*"

Is the Moderate Use of Alcohol by a Nation possible? —
In America, those who use alcohol often refer to Germany and other European countries where they suppose the people have found it possible to use alcohol without going to excess. Professor J. H. W. Stuckenberg, of Harvard University, has translated most of the following statements by Germans:¹

PRINCE BISMARCK: "Beer makes people stupid, lazy, and incapable." (*Bier macht dumm, faul, und impotent.*)

PROFESSOR HELMHOLTZ: "Beer instantly dispels my best ideas."

G. ASMUSSEN, C.E., *Builder of the Celebrated Docks at Hamburg*: "Herr Wurm, member of parliament, still believes in the old brewer theory, that 'good' beer will banish brandy and prevent ruin. Another Bavarian, generally regarded the most eminent authority in the department of hygiene, Prof. Max von Pettenkofer, says the contrary. He has repeatedly declared that the above opinion does not conform to fact; that the increased use of beer, not only fails to diminish the use of brandy, but that the alcohol swallowed in beer produces the same drunkenness and a variety of beer diseases into the bargain."

F. VON BIRCH-HIRSCHFELD, M.D., *Professor of Pathology in the University at Leipzig*: "Based upon my experiences, I have come to the conclusion that in Leipsic, as in other large cities, a very great proportion of our laboring men, perhaps one-half of our masculine population twenty-five years old and upward, manifest more or less organic injury resulting from the use of alcohol. *They show, without exception, a decrease in the number of tissue cells with a corresponding loss in power and endurance.*"

GUSTAVE VON BUNGE, M.D., *Professor of Physiological Chemistry, University at Basle*: "The predisposing cause of the drink habit is

¹ There are no italicized statements in the originals.

not wretchedness. *The main cause is the imitative passion among men. The first glass of beer is no more to our liking than our first cigar. Persons drink because others drink.* But, after the habit has been formed, there is never any lack of excuses for taking a drink. People drink when they meet; they drink when they part. They drink when they are hungry to quiet hunger; they drink when they are surfeited to arouse appetite. They drink when it is cold for warmth; they drink when it is hot to cool off. They drink because they are sleepy to keep awake; they drink when they cannot sleep to induce sleep. They drink because they are sad; they drink because they are jolly. They drink because there is a baptism; they drink because there is a burial; they drink and they drink. Why shouldn't they also drink to forget care, poverty, and wretchedness?

"But among all excuses to drink, the latter is the silliest. A man wants to do away with an effect, and increases the cause. He wants to vanquish poverty, and contracts the habit of spending money in a way that interferes with his capacity for work and for making money. He wants to overcome anxiety and care, but instead of going to some true friend who can lend support by means of counsel and help, he resorts to false friends at the saloon who say, 'You are not at fault; it's the condition of the country,' and who kick out the solace-seeker as soon as he is no longer able to pay his bill for drink.

"Every three years the German empire expends for beer, the war indemnity it received from France, five billions; in addition to that it consumes annually even more distilled liquors per capita than Russia, so notorious for whiskey drinking. In Germany the number of people who are annually sent to hospitals for chronic drunkenness and delirium tremens is increasing at a frightful rate, attaining for the last year for which we have statistics, 11,974 (1885, see Baer). And now bear in mind that it is only the smallest proportion of the toppers who consent to enter the hospitals.

"Even the most moderate drinker is like a man who exclaims: 'I am never dizzy, it is fun for me to keep my balance on the edge of a precipice. I oppose having any railing around. Suppose every ninth man does fall down and dash out his brains — what's that to me?' The fall of a drunkard is often much more shocking and horrible than that from a precipice, because the drunkard may leave a degenerate offspring to be slowly tortured to death. But, finally, what is the use of moderate drinking, of keeping one's balance on the edge of a precipice? That the moderate use of alcohol is destitute, absolutely, of any value, is apparent to every total abstainer. It is a duty to build around a precipice a strong railing. That railing is total abstinence."

ADOLF FICK, M.D., *Professor of Physiology, University of Wurzburg, Bavaria*: "We often hear dissuasion from the use of alcohol condemned as blameworthy. They say wine is a noble gift of God, and it is sinful to reject instead of to receive it with gratitude. It is hard to believe any one in earnest who makes this statement. *We may call the grapes a noble gift of God; wine certainly is not*, for we never obtain this liquid from the grape except by artificial means specially designed, by means of a process much resembling rotting, in coöperation with germs that have been added.

"About two years ago a friend of mine who had come to Wurzburg on jury duty came to my house from a session of the jury, and these were his first words: '*Remarkable, in every crime that comes up before us during this session, alcohol has played a part!*'"

AUGUST FOREL, *Professor of Mental Diseases, University of Zurich, Director of Insane Asylum, Burghozli, near Zurich*: "**Not abstainers, but the advocates of the possibility of universal moderation are the visionary people.**

"Become a total abstainer from alcohol; you will find yourself happier, healthier, and stronger; you will be rid of just one more kind of slavery; you will not only keep your high spirits, feel jolly and sociable, but these qualities will improve in every way. You will become susceptible to the higher and more refined enjoyments, physical as well as intellectual.

"Where is the boundary between the drunkard and the moderate drinker? *Nothing appears to me more ludicrous now than the contemptuous attitude the moderate drinker assumes toward the toper. Do not the number of deaths from fatty degeneration of the heart, diseases of the vessel walls, delirium tremens, the hardening of the liver, preach loud enough that our drinking customs are ruining our bodies and shortening our lives?*

"The rôle alcohol plays in student life is one of the darkest chapters in this dark history. This I can affirm, that *in Germany, Switzerland, and Austria, yes, and in France, a large part of the intellectual power of our academic youth is actually drowned in beer and wine.* The ridiculous drink compulsion and idiotic vainglory at the drinking festivals German students have introduced are undoubtedly the most hideous deformity of our civilized century. At the same time, they are a revelation of the mental deficiency among our university students, the intellectual hope of our nation. *Students often poke fun at the Paris fashions of the woman world*; — I am also heartily opposed to their bad taste in uniformly aping one another, according to the change of season, which, by the way, *has this in common with the drink custom*:

it puts money into the purses of a few schemers;—but how much more stupid, and in how much poorer taste, are the students' drinking fashions! People call it jovial. Yes, a pretty joviality, with its accompaniment of palsied tongues, staggering, fighting, vomiting, in which imbecility is applauded and beastliness and misdemeanors are excused and glossed over."

FRIEDRICH LUDWIG JAHN, *Founder of the German Turn Verein*: "We must again train our young men to remain real youth that will disdain to engage in even allowable pleasures if these only befit the mature years. The emotions must be kindled to love of nature, so that they will experience more satisfaction in simplicity than in the drinking shops, where they will become dull and nerveless. In Freiburg, with its more than 1,000,000 grapevines, I still manage to get along as a water drinker."

K. KROHNE, D.C.L., *Privy Counselor, Director of the Prison at Moabit in Berlin*: "Is the liberty of a man to ruin himself and family through drink, and to endanger the safety of society, the very highest ideal of personal freedom, that we are obliged to treat it as something that dare not be disturbed? Even after a father has become a drunkard, allows his wife and children to go hungry, beats them, lets his children run wild, when the family ruin is plainly evident, article after article of furniture being pawned, the wretched wife sees her last bed carried away, the family falls upon the town, the father becomes a criminal, and brings up a family of criminals,—even then we are not allowed to force the whiskey bottle from his hands."

JUSTUS VON LEIBIG, *Chemist*: "It is now possible to demonstrate with mathematical certainty that, so far as enriching the blood is concerned, *the flour that will lie on the point of a knife affords more nourishment than four measures of the best Bavarian beer*; and that anybody who drinks a measure of beer daily would imbibe in one year about as much nourishment as is contained in a pound of bread."

MARTIN LUTHER: "The first man to brew beer was the pest of Germany (*ille fuit pestis Germaniæ*). I have often execrated the one who first brewed beer. Brewing spoils enough barley to keep Germany."

P. J. MOEBIUS, M.D., *Nerve Specialist, Leipzig*: "The fact is, all this talk about the nutritive value, the strengthening and curative properties of alcohol, *is nothing but a cloak the drinker employs to conceal his appetite*. If people didn't care about drinking, nobody would concern himself about the trifling nutriment claimed for alcohol."

"The people ought to be enlightened about the old pretenses that alcohol nourishes, warms, strengthens, aids digestion, cures; they all amount to nothing. Those engaged in the manufacture and sale of liquor are a great power — wine producers and sellers, brewers, distillers, tavern-keepers, and all their hangers-on. The parents' efforts ought to be supported by the teachers, and it is the duty of the clergy to serve the cause, not only by precept, but also by force of example. It is of greatest importance that doctors should take the right stand. Alas! until the present, as a whole, they have not recognized their duty in relation to drunkenness, but by their foolish recommendations have promoted the esteem in which alcohol has been held. To be sure, we must acknowledge that they have mostly done so in good faith, — correct understanding of the effects of alcohol has not been acquired until recently, and it has not yet become the common property of all physicians. *But, at this day, every physician ought to be ashamed to recommend a 'medicinal wine' (there is no such thing as a medicinal wine), or, what is more, to recommend wine as a tonic for children. Those who prescribe a special brand of liquor for the grippe and the like, don't know what they are about. Every physician is in duty bound to be strictly temperate; if he were a total abstainer, his example would be more effective than that of others.*"

L. SONDEREGGER, M.D.: "*Thousands boast that they never drink much, especially the toppers; nobody can tell them the truth without suffering for it. In this, also, the most respectable are the most terrible sinners; never quite drunk, but daily filled with drink, they are like a steam boiler heated to the last point of pressure, trembling under the strain, just waiting for the impulse to cause an explosion. Look at this plump, glowing, red-cheeked man; he is as nervous as an anemic girl, sleepless, out of humor, bored and unhappy under brilliant circumstances; a slight illness or accident would take him to his grave.*"

"*The chief opposition towards all anti-alcohol measures proceeds from people concerned in the business, especially from the manufacturer of liquor, to whose influence it can be ascribed that so little has been accomplished.*"

The Body has a Remarkable Power of Adaptation. — Man can adapt himself to more climates and conditions than any other animal, the dog perhaps ranking next in this respect. If a person habitually eats too much, his stomach becomes enlarged to accommodate the food. If

then he eats a smaller but sufficient amount of food, he still has a craving for enough to fill the distended stomach. In a few days the stomach shrinks back to its normal size, and the appetite also becomes normal. The body adapts itself to unhealthy conditions too readily for its own welfare. Confinement and idle muscles make a man restless for a few weeks, but if he represses the good instinct he soon loses all desire for healthful activity. He even gets an aversion for it, although it may be just what his health demands.

Adaptation to Poisons.—Mithridates, king of Pontus, suspected his enemies of intending to poison him. He therefore took poison in gradually increasing doses, hoping his body would become so used to poison that he could not be poisoned. Doubtless, as with the users of alcohol and nicotin, he soon had a craving for the poisons, however repulsive they may have been at first. The body seems to learn to defend itself against poisons. The cells burn up the poison or throw it off, or even learn to tolerate it, yet their vitality is doubtless injured by the task. Some people believe that this adaptation to alcohol and tobacco means that they are harmless or even beneficial; such people generally have the habit of using them.

People with Bad Habits who live to Extreme Age.—The power of the body to defend itself against stimulants and narcotic poisons is greater if the person using them leads an outdoor life. *The oxygen* of the pure air helps to burn them up, the muscular exercise of an outdoor life keeps the skin active and some of the poison is excreted. We sometimes hear of people who live for a century in spite of using tobacco. Such people have lived out-of-doors a great deal, and none of them used cigarettes when children. A greater number of temperate than intemper-

ate people live to an advanced age. Pure air and an active life enable the body to free itself of its own natural waste material and of narcotics as well. Old age comes on from hardening of the arterial walls by the deposit of mineral and other wastes. A man is said to be "as old as his arteries." The same amount of tobacco that would in a few years ruin the health of a man working in an office may not have a great effect upon a farmer.

Presumption and Ignorance.—Many people think they are capable of tracing the effects of every bad habit and of every drug, and of measuring exactly what the effects are. Most people who use alcoholic drinks and tobacco say that the habits do no harm; a few even say that such things benefit the health. *Either the harm done in their cases is so gradual that it is not noticed, or it is great and they attribute it to something else.* Rheumatism, indigestion, fatty degeneration of the tissues, kidney troubles are among the more marked but often unsuspected effects of alcoholic drinks. Perhaps the most important result of the right study of the body is the realization that our ignorance of the body is many times greater than our knowledge of it. People who have only made a thoughtless study of physiology imagine that the body is a very simple machine and if it goes wrong the disorder can be remedied in a twinkling. If one has a bad cold and walks down the street almost every acquaintance he meets can suggest an "infallible cure," simply because he took it once when his cold was going to get well anyway, and his cold ceased. Because a man was sick and took a certain drug is not proof that it cured him; its narcotic or stimulant effect may have delayed the cure. Another man may fall sick, take the same drug, and die; yet this is not proof that the drug helped to kill him; we do not know. So many people would not be foolish enough to believe patent

medicine advertisements if they did not think they were capable of prescribing for themselves. They take drugs confidently upon the advice of a druggist, while a physician, who has devoted years to the study of drugs, often prescribes with doubt and hesitation. The alcohol or opium in the patent medicine deadens pain, and the user writes a glowing letter in its praise. When he becomes worse he will never attribute the effect to the medicine.

The science of physiology teaches that the cells have built the body to its present size, that they sustain it, that they repair wounds and broken bones, and only they can heal the body. No patent medicine vender can know what is being done by these wonderful little workers, and he manufactures no cure-all that can surpass them. Fevers, inflammations, and other diseases are attempts of the cells to burn up or expel poisons, germs, and waste material. We can aid the cells best by pure air, simple food, cleanliness, rest, and healthful activity. To stop the inflammation or fever before it has done its work is to thwart the efforts of the cells and perhaps to change an acute disease into a chronic one. The best physicians give as few drugs as possible, especially if the intelligent coöperation of the family enables them to use better means. It seems a wonderful and skillful thing when a person is racked with pain to have it cease after a physician or other person gives a small dose of opium or other narcotic drug, but any blunderer can do it. Narcotic drugs merely paralyze the healing efforts of the cells, hide the disease, and leave the physician in darkness as to its progress. Skillful physicians do not interfere with the healing efforts of the body itself but coöperate with them. Tens of thousands of morphine users in our country with lives hopelessly wrecked are one of the results of prescribing opium.

Stimulating the Mucous Membrane.—Calomel stimulates the epithelial cells lining the food tube. It is a mineral poison containing mercury, and the cells pour out mucus profusely to wash it away and prevent being injured (see the dark cells in Fig. 7). When the body is being relieved of the calomel it likewise is saved from absorbing undigested food which has fermented in the intestine and formed poisons. *Thus a spell of sickness may be prevented;* but it is done at the expense of exhausting and injuring the intestinal lining, and the intestine may soon become more torpid than ever. If, in spite of the efforts of the cells, calomel is absorbed into the circulation, it may cause a loosening of the teeth and salivation, which is a profuse flow of saliva to aid the removal of the poison. Dyspepsia and thin blood often result from taking purgative medicine. In some cases the cells become so weakened that they will not secrete at all unless calomel is taken regularly.

Evils of Home Dosing.—When any one begins to feel bad he should heed the warning promptly and find the fault in his way of living and correct it, whether it be in eating, working, or otherwise. In some families ignorant of hygiene or too lacking in self-control to use it, parents are ever ready for home doctoring instead of teaching the children to live in a better way. A drug, such as calomel or a patent medicine, is taken whenever any one feels bad. As a result of the periodic dosing, there is usually not a rosy-cheeked child in the family, — their teeth are bad, their blood is thin.

Relation of Drugs to Hygiene.—When a person has the habit of working little and eating much, the food tube becomes overloaded, the food changes into a sour or fermenting mass, the moldy growth soon coats the tongue, the appetite is gone, and the person is almost prostrated

with poisons absorbed from the food tube (a condition usually given the absurd name of "biliousness"). If he takes timely warning, drinks plenty of water, ceases to eat until his appetite returns, he may soon be well again. If he goes on until he becomes ill in bed, his chance for helping himself is lost; a physician should be called and his directions implicitly obeyed. A person who has not wisdom and prudence enough to use pure air and water, simple food, and exercise to keep himself well is not wise enough to use drugs. Drugs usually are violent poisons; a physician only is competent to give them. A man takes a drug which relieves the food tube; he feels better for the time; instead of being ashamed of his wrong way of living he is very much elated at his skill and feels very wise. He is encouraged to live as before instead of resolving to learn, if possible, to take care of himself. *Until the laws of hygiene are better understood and more fully believed in, drugs will have a useful place.*

Sixty years ago it was the custom to bleed patients for nearly every ailment. This made the cells hungry and set them to work, and enabled a careless man to resume his habit of eating much and working little. So violent a remedy often repeated weakened the cells. Bleeding doubtless saved life, yet it, together with the large doses of strong drugs which next became the custom, seems to have weakened the body of civilized man so that now bleeding is never, and large doses seldom, resorted to. Drugs are recognized as useless in consumption and a number of other diseases. Drugs with a narcotic or stimulant effect are given in smaller and smaller doses; alcohol is hardly ever given by physicians of the present day. At this rate, in fifty years a physician will as rarely think of using a poisonous drug for medicine

as a physician now thinks of drawing blood from a patient in order to heal him. Already baths are in general use for reducing fevers. Dieting, rest, massage, and other hygienic measures are more and more relied on by physicians as the intelligence of the people allows it. There are fewer patients now than formerly with superstitious dread of fresh air and cold water and boundless faith in strychnin, arsenic, calomel, alcohol, and other dangerous drugs.

Not Certain Stimulants and Narcotics but a False Belief must be Destroyed.—If opium were destroyed, cocaine might be used in its place; if tobacco were no longer grown, excessive use of coffee might result. Arsenic, strychnin, quinine, etc., are each used as stimulants by some people. In Brazil, coffee is used in place of alcohol. Twenty and thirty cups are drunk by one person in a day. The Brazilians say that coffee to be good must be as “black as night, as bitter as gall, and as hot as fire.” So long as a false trust in stimulants and narcotics exists it would be an endless task to drive them out of use one by one only to be replaced by another. People used to seek the “philosopher’s stone,” which would turn all it touched into gold; the search for the “fountain of youth” and the “elixir, or water, of life” has been abandoned. In our time the search for the fountain of health in stimulants, narcotics, and tonics is as common and as fruitless as the foolish quests of other times. Pure food will give strength, alcohol will not; exercise is a natural stimulant to the circulation, strychnin is not; fatigue is a good narcotic and brings healthy sleep, opium will not; right thoughts will cure nervousness, tobacco will not, but will make one more nervous still.

Natural living is all that will insure health. It is as

necessary for a wealthy man or a learned man to use his muscles to make his blood flow as it is for a poor man or an ignorant one. Worry and anxiety will break down nerve strength, and nothing but peace of mind, pure air, and simple food will build it up. Most people are wise enough to take care of their health if they lead simple natural lives; no one is wise enough to take care of his health if he leads an artificial life. Deadening narcotics and stimulants may postpone the ruin, but it will be all the more complete and hopeless when it comes. A man who cannot take care of an ax, and allows its blade to rust and its handle to rot, is not wise enough to interfere with nature by using hot seasoning when he has no appetite, taking a stimulant when he is tired and a narcotic when he is restless from using his brain too much and his muscles too little.

Doing is More Difficult than Knowing.—The clearest and most convincing argument against the use of alcohol, and the most vivid descriptions of its ruinous effects contained in any text-book, were written by a university professor who afterward died a miserable drunkard. Every boy who studies the destructive efforts of alcohol as outlined in this book will doubtless resolve never to touch it. He should make the resolution with a determination to keep it, in spite of the ridicule of ignorant acquaintances or the example and persuasion of so-called friends.

EXERCISES IN WRITING.—Why I believe in studying Physiology. A Home having an Intelligent Housekeeper. A Home having an Ignorant or Careless Housekeeper. A Graceful Form. Why Some People are Unhealthy. Which is a Surer Sign of Lack of Wisdom: Poverty, the Inability to make Money, or Ill Health, the Inability to take Care of the Body? Good Habits. Natural Means of Cure and Drugs. The Body a House. The Mind and Health. Why Illness is so Common? Several Kinds of Health Cranks. Why I stopped Smoking.

CHAPTER IX

THE SENSES

Review Questions introducing this Chapter. — Where in the skin do the nerves end? What evidence is there that we have separate temperature nerves for hot and for cold? How can the temperature nerves be trained? What feeling warns us to take exercise? To cease? Does hunger show merely a condition of the stomach? Where are papillæ found in the skin? What do they contain?

The five special senses, as usually named, are touch, taste, smell, sight, and hearing. The temperature sense should be classed as a sixth special sense. All other sensations are classed as general sensations.

Five Differences between Special and General Sensation. — First, the nerves of special sense all end in special organs at the surface; for instance, the touch corpuscles are for touch, the eye is for sight, etc. There are many nerves in the body that do *not end in special organs*; these nerves give what is called general sensation. A second difference is that general sensation *tells of the condition of the interior of the body*, while special sensations tell us of the condition of the surface of the body and of the outdoor world. Third, *general sensations are not so exact* as the reports of the special senses. One can locate a point on the skin that has been touched much more accurately than he can locate an internal pain. A fourth difference is that the meaning of each special sensation must be learned (usually in infancy); but the *meaning of general sensations is inherited*. This inherited knowledge of what general sensations mean is also called instinct.

Fifth, the *sympathetic nerves usually bring general sensations*; the spinal and cranial nerves usually bring special sensations.

Examples of general sensations are hunger, thirst, satiety, nausea, faintness, giddiness, fatigue, weight, aching, shuddering, creepy feeling, tingling, sleepiness, pain, illness. Any nerve can convey the general sensation of pain, if injured along its course. If a nerve of touch is cut, there is no sensation of touch, but of pain. Touch sensations come only from the ends of the nerves. General sensations are of many kinds.

We are only half conscious of some of them; many of them are hard even to describe.

Hygiene of the General Sensations.—General sensation is an invaluable aid to the health. Without it as a guide, the body could not remain alive a single day. *Pain* should be heeded as our best friend, and not killed

with poisonous drugs as if it were our worst enemy. We should not deaden the stomach ache with an after-dinner cigar. If we do not go to bed when sleepy, the *desire for sleep* may leave us, and we will undergo untold suffering from sleeplessness. *Thirst* should be satisfied with cool water, which quenches it the best: he who makes his teeth ache with ice water will inflame his stomach and be continually thirsty. He who does not stop eating when his

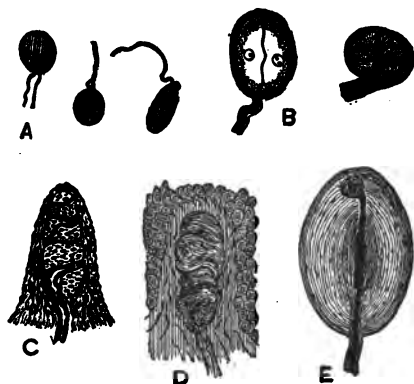


FIG. 161.—DIFFERENT KINDS OF TOUCH BODIES AT ENDS OF NERVES.

A, from cornea of the eye; *B*, from the tongue of a duck; *C*, *D*, *E*, from the skin of the fingers. (Jegi.)

hunger is satisfied will distend his stomach with food, and the stretched organ will be harder to satisfy thereafter; in fact, eating after a feeling of satiety may cause indigestion so that the cells will not get the food. A dyspeptic is always hungry, for the cells are starving. *Fatigue* of body or mind gives us wise counsel; but this feeling may be deadened by alcohol or tobacco, and work continued until the body is injured. We should heed the warning of pain or fatigue as promptly as an engineer heeds a red flag on the railway track. One who uses narcotics acts like a reckless engineer who removes the danger signal and goes ahead, hoping by good luck to escape an accident.

Most of the **nerves of touch** end in papillæ of the dermis as *microscopic, egg-shaped bodies* (Fig. 186). There are also many in the interior of the mouth, especially on the tongue. On the palms they are arranged in curved lines, and on the tips of the fingers they are in circular lines, with one papilla in the center. The delicacy of the sense of touch varies very much in different parts of the skin. *This delicacy refers to two things*: the ability to feel the slightest pressure and the ability to tell the exact point of the skin that is touched. A lighter pressure can be felt on the forehead and temples than with any part of the body. (Why is it best for this to be the case?) The greatest ability in locating the point of the skin touched is possessed by the tip of the tongue, the lips, and the ends of the fingers. (Why is it best that this is so?) This is dullest in the middle of the back. Its delicacy varies with the number of touch corpuscles in different parts of the skin. This sense is capable of great cultivation. Blind people read by pressing their fingers over raised letters, yet if you tried, you could not feel the difference between the letters.

Experiment 35. Open a pair of scissors so that the points are one eighth of an inch apart, and touch both points to the tip of the finger. Are they felt as one or as two points? Find how far they must be separated to be felt as two points when applied to the back of the neck. Caution: The person should be blindfolded, or should look away while the tests are being made. Two pins stuck in a cork will be more convenient to use than scissors.

The temperature sense has been discussed in the chapter on the skin. Review the topic on the thermic nerves. That the *thermic nerves are easily fatigued* is noticed soon after entering a bath of hot water; it is also shown by the fact that in cold countries the nose or ears of a person may freeze without his feeling it.

Warm objects give heat to the skin, hence they feel warm. *Cold objects take away heat* from the skin, and feel cold. The temperature nerves end throughout the skin (Fig. 162) and in the mucous membrane of the mouth, pharynx, gullet, and nostrils. Why are they needed in those places? *The skin, cheeks, eyelids, and elbows are especially sensitive to heat and cold.* The laundry woman tests a hot iron by holding it near her cheek. A nurse tests the water of a child's bath with her elbow. In washing the face with water that is too hot the eyelids suffer most. The eyes are easily injured by heat; hence this provision for their protection. Glass blowers disregard this feeling, and many of them go blind by the time they are forty years old. Students find that hot, dry, stove-heated rooms or hot lamps cause trouble with the eyes.

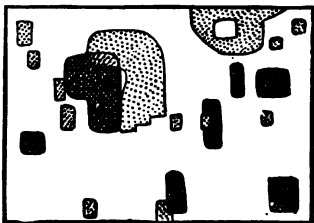


FIG. 162. — "Cold" spots (light shading). "Hot" spots (dark), skin of thigh.

The Muscular Sense. — There has been much discussion as to whether this is a special sense. No special end organs have been discovered, and *it partakes of the nature of general sensation. The special sense of touch gives some sense of weight.* A weight upon the skin must be increased by one third before it feels heavier, but by lifting an object so as to *bring into action the muscular sense residing in nerves ending in the muscles* an increase of only one seventeenth of the original weight will be noticed. This sense gives us a continual *account of the position of the limbs.*

Experiments. — 36. Make tests of the ability to distinguish the weights of objects weighing nearly the same. 37. Close the eyes and let a friend move your arm a few inches; then see if you can, with the other hand touch the hand in its new position at the first attempt.

REVIEW BASED ON FIGURES. — A number of pupils may draw upon the blackboard and explain the following figures: 2, 7, 10, 20, 32, 43, 44, 48, 49, 52, 55, 85, 90, 93, 99, 100, 101, 102, 104, 105, 107, 108, 109; 112, 116, 117, 118, 120, 121, 123, 124, 125; 131, 133, 135, 136, 137, part of 138, 141, 142 A, 144, 145, 146, 150, 151, 152, 154, 157, 159, 160, 162.

THE SENSE OF TASTE

The end organs of taste are located in the papillæ of the tongue. The tongue has a fuzzy look because of the numerous papillæ. The papillæ on the tongue are of three kinds (see Fig. 163, also use a mirror). 1. The *threadlike papillæ* are numerous on the sides and tip of the tongue, and are believed to be of use chiefly in touch. 2. The *mushroom papillæ* are larger but less numerous than the threadlike papillæ, and are scattered among the latter on the sides and tip of the tongue. 3. The large *walled papillæ* number only eight or ten, and are situated in a V-shaped line far back on the tongue, with

the point of the V toward the throat. Each one is surrounded by a ditch, and beyond this, a wall of mucous membrane. The nerves of taste end in the last two classes of papillæ.

The principal tastes are only four; namely, sour and sweet (tasted chiefly by edges of tongue), saline and bitter (tasted on the back

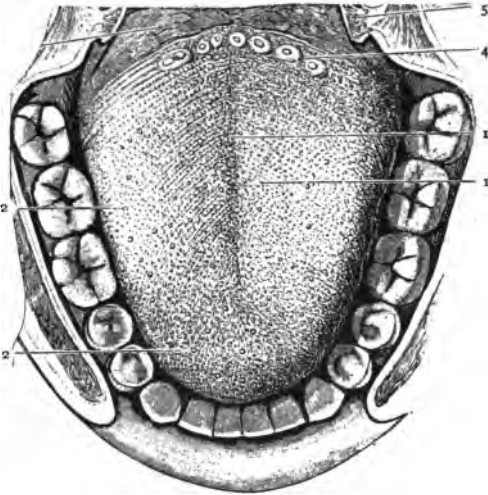


FIG. 163.—THE TONGUE AND LOWER TEETH.

1, 1, thread-like papillæ; 2, 2, mushroom papillæ; 4, walled papillæ; 5, tonsil.

of tongue).

Experiments.—38. Put a little vinegar on the back, tip, and edges of the tongue. Where is the taste strongest? 39. Try sugar, salt, and quinine in the same way.

The nerves of smell end in the mucous membrane of the upper half of the two nasal chambers (Fig. 164); the *fibers are spread over the upper proportion of the walls*. The direct

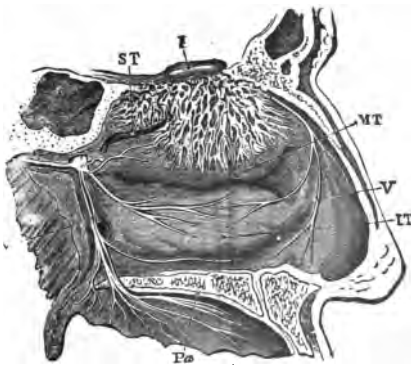


FIG. 164.—OUTER WALL OF LEFT NASAL CAVITY.

Olfactory nerve forms a bulb, *I*, on the floor of the skull. The fibers branch from this bulb like the roots of an onion and spread out on the walls of the nasal chamber. *St*, *Mt*, *It*, turbinate bones. *Pa*, hard palate.

current of air does not pass as high as these nerve endings; hence sniffing aids the perception of odors. This sense is able to bring up the associations of early life more powerfully than any of the senses. The odor of a flower like one that grew in an old garden can almost restore the consciousness of the past. *We smell gases only*; solids and liquids cannot affect the nerve.

Flavors.—The tastes that we call flavors are really smells. We confuse them with taste, because they accompany food that is in the mouth. Name some foods that seem “tasteless” when one has a severe cold in the head. Why is this? Some of the most repulsive drugs can be easily swallowed if the nose is held.

Experiment 40. Mark *F*, *T*, or *FT* after the following foods, according as they have flavor, taste, or both: vanilla, apple, lemon, beef, peaches, grapes, coffee, onion, potato, cinnamon. A good test for the presence of flavors is whether they can be smelled without being chewed.

Experiment 41. Blindfold a member of the class, and while he holds his nostrils firmly closed have him place successively upon his tongue a bit of apple, potato, and onion. Can he distinguish them?

HYGIENE OF THE SENSES OF TASTE AND SMELL

Their Value as Guides.—A savage or a beast uses the senses of taste and smell to find out whether things are good to eat or not. If a civilized man's senses are not perverted, and he eats only simple foods that have a pleasant taste, they will not injure him or cause him sickness. Things that are poison usually have an unpleasant taste and often have an unpleasant odor. These senses

are naturally of wonderful delicacy. They can be cultivated to a still more remarkable degree, or they can be blunted and almost destroyed.

Experiment 42. Blindfold pupils and test the sense of smell with perfumes, fruits, extracts, flavors, drugs, etc.

How the Sense of Smell is Injured. — Some persons live so carelessly as to bring on a constant succession of colds. By continuing in faulty ways of living, the colds change into *a chronic catarrh which so affects the mucous membrane* in the upper part of the nose as to dull or destroy the sense of smell (see Fig. 164, also Fig. 165). Then the enjoyment of delightful odors and agreeable flavors is impossible, and the body loses an ever vigilant protector placed as a sentry to warn against the admission of poisonous food and gases.

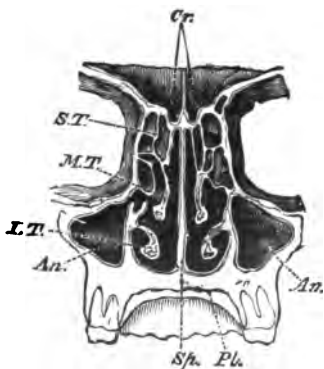


FIG. 165.—CROSS SECTION OF NASAL CHAMBERS.

Effect of this Injury upon Habits of Eating. — The loss or even the weakening of the perception of flavors is an injury to the working of the closely related sense of taste. When a person loses the enjoyment of delicate flavors, he wants food to have strong seasoning and more decided taste to prevent it from being insipid. Everything must be either very greasy or very sweet or very salty or very sour, to please his degenerate senses. Wheat, corn, and other grains have each its own pleasant taste, yet such persons must have lard in their bread because they are not capable of appreciating anything with a delicate taste. In England, butter is not salted and its delicate taste is enjoyed ;

in America, salt is added to preserve it, and most people have come to prefer the strong taste of salty butter to the delicate taste of pure butter, and do not like it unless its true taste is partly hidden by the taste of salt.

Bad cooks have injured our perception of tastes and of flavors by making mixtures that confuse the senses. After they drive off the flavors by overheating, they have to add vinegar, grease, etc., to prevent the food from being entirely without taste or flavor. In Spain, the cooks mix foods together more than in many countries, and give most dishes a strong odor of garlic in an attempt to undo the evil. In Mexico, enormous quantities of hot pepper are used. Many persons have catarrh of the stomach in consequence. Would you say that a kitchen from which savory odors of the food permeate the neighborhood during the time of cooking, contained a good cook or a poor one? Should flavors be driven off or retained in the food? Often, because of strong seasoning, people eat more than the body demands. Tender lettuce, water cress, etc., are palatable without seasoning, and too much will not be eaten, but the stomach is sometimes overloaded with tough weedy vegetables like turnip tops, cabbage, etc., because of the high seasoning. For one to know how much of such foods he really likes, he should try to eat them without mixing condiments with them.

Deceiving the Sense of Taste. — The habit of using narcotics like *tea* and *coffee* is usually begun by concealing the repulsive bitter taste of the substance by mixing sugar, cream, and other agreeable things with it. Licorice is sometimes mixed with *tobacco* to weaken its biting taste. *Pure alcohol* would never be drunk by any one who had the least respect for the sense of taste, but the agreeable flavor of grapes, apples, and other fruit which still remains in

wine, cider, and brandy, conceal the repulsive taste of the alcohol. *Beer* has the insipid taste of grain which has undergone decomposition or partial rotting, and hops are added because the strong taste of hops obscures the stale, insipid taste of the rotted grain. *Eggnog* is made of eggs, a nourishing food; sugar, which has an agreeable taste; water, a refreshing drink; and alcohol, a fiery poison. A very good eggnog is often made without alcohol, but a good one could hardly be made with any of the pleasant ingredients left out. The best eggnog is made by using the fresh juice of lemon, orange, or grape, instead of alcohol.

Effect of Narcotics. — Tobacco, alcohol, opium, and other narcotics dull the senses of taste and smell and prevent the enjoyment of delicate flavors. They accomplish this as much by their effect upon the brain as upon the nerves themselves.

It is Wrong to eat Food that is not Relished. — Unpalatable food is not likely to be well digested. It is a law of the body that *the food which is enjoyed the most is digested the best*. This applies to food with its own honest taste, not to food disguised by the taste of something else. The rule does not apply to a taste perverted by having been forced to become accustomed to poisonous things. People who munch their food slowly enjoy the pleasures of taste the most, and digest their food the best. The nerves of taste and smell easily become fatigued. The first whiff from a cologne bottle is the strongest. Highly flavored foods should be eaten moderately, if we would obtain the greatest enjoyment from them.

THOUGHT QUESTIONS. — **1. Interfering with the Body.** What is the natural direction of growth of the big toe? **2.** Think of six evil results, direct or indirect, which will follow from displacing it by tight

shoes. (p. 67) 3. Which part of the spinal column, designed in infinite wisdom to be most flexible, do some people try to make the most inflexible? 4. The mobility of the false and floating ribs was intended as a blessing. Some people interpret the blessing as an opportunity to do what? 5. Name six articles which warn us to avoid them by their bitter, burning, or nauseating tastes, yet which are used by man. 6. Name six feelings which are intended as warnings for our guidance, but which are commonly disregarded.

THE EYE AND SIGHT

Sound reaches the ear by means of a trembling, or shaking, in the air called *sound waves*. **Light** reaches the eye by means of tremblings, or waves, in a fluid much thinner than the air, called the *ether*. Ether fills the space between the particles of air. High up above the earth, where air no longer exists, the ether alone is found; it extends to the sun, moon, and stars, and brings energy from them to us in the form of light. The waves of light make no impression upon any nerve except the nerve of the eye, called the *optic nerve*.

The sense of sight enables us to avoid dangers when we move about, to judge of the distances of objects, to observe the various forms of material things, and to enjoy the varying lights and shadows, colors and tints.

The eyeballs are globes about an inch in diameter. They are placed in deep, bony sockets, called *orbits*, in the front part of the skull (Fig. 43). The optic nerve, other nerves, and several large blood vessels pass to the eye through a hole in the back of the orbit. A soft cushion of fat is in the orbit behind the eyeball. A pressure upon the eyeball causes the eye to sink into the socket, for the fat yields to the pressure. This is a protection to the eye. In heads of the same size, there is very little difference in the size of the eyeballs.

The reason that some persons appear to have much larger eyes than others is because some eyes are not set so deep in the sockets, or because some persons keep the eyes wide open, while others keep the lids partly closed over the ball. The eyeball itself has hardly any power of changing its expression. The expression of the eye comes from the movements of the ball and lids.

The eyelids protect the eyes from dust, and at times from the light. They are aided in this by the eyelashes.

The tears are formed by *tear glands* situated above the eyeball in the portion of the orbit farthest from the nose, just beneath the bony brow where it feels the sharpest (Fig. 166). They are about the size of almonds. A saltish liquid is continually oozing from the tear glands and passing over the eyeball; it is carried into the nose through the *nasal duct* (Fig. 166). The tears reach this

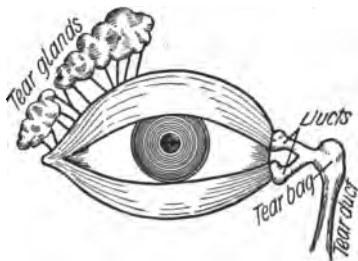


FIG. 166. — TEAR GLANDS AND DUCTS of right eye. (Jegi.)

duct through *two small canals*, which open into the eye in the little fleshy elevation at the inner corners of the eye (Fig. 166). The opening of one of the canals may be seen by looking into a mirror. Sometimes these canals are stopped up, and what is called a “weeping eye” results. A temporary stoppage may occur during a cold in the head. Sometimes, under the influence of anger or other strong emotion, the tears may be formed so fast that they cannot be carried to the nose and they flow down the cheek. Usually the tears are evaporated on the warm mucous lining of the nasal cavities. A crying child makes frequent swallowing movements (spoken of

as "gulping down his anger"); these movements are caused by the need of swallowing the extra tears that reach the throat. The front of the eye is as transparent as clear glass; the lids and the tears help to keep it clear by performing a service for it like that which a servant performs who, with cloth and water, frequently polishes a plate glass window. Tears prevent friction between eye and lid. Winking applies the tears to the ball. Small glands along the edges of the lids form a kind of oil which usually prevents the tears from flowing over the lids. Sometimes this oily secretion is so abundant, especially during sleep, as to cause the lids to stick together.

The globe of the eye consists of its outer wall and the soft contents within the wall (Fig. 167). The wall has three

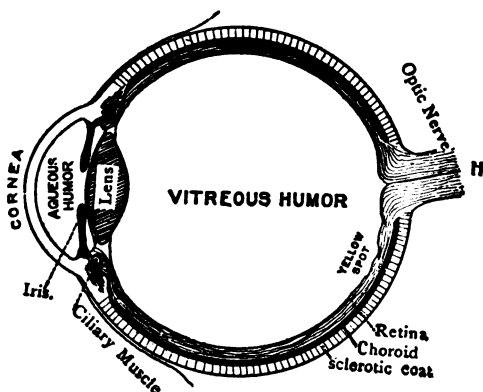


FIG. 167.—THE ANATOMY OF THE EYE.

layers or coats, and the contents are in three divisions.

The outer coat is the tough *sclerotic* (Greek, *skle-ros*, hard), composed of dense connective tissue. It gives strength and firmness to the eyeball. It

shows between the lids as the "white of the eye." It is white and opaque except in front; there it bulges out to form the transparent *cornea*. This clear portion of the wall may be seen by looking at the eye of another from the side.

The second coat, called the *choroid* (Fig. 168), consists of blood vessels and a loose connective tissue containing many dark brown or black pigment granules. The choroid absorbs light. Cats' eyes shine at night because this coat in their eyes reflects some light. The choroid separates from the sclerotic toward the front of the eye and forms the colored *iris*. The iris makes the eyes beautiful, and it also serves the useful purpose of regulating the amount of light. The hole in the iris is called the *pupil*.

The third and innermost coat, called the *ret'i-na*, is the most important and characteristic tissue in the eye. It is made by the fibers

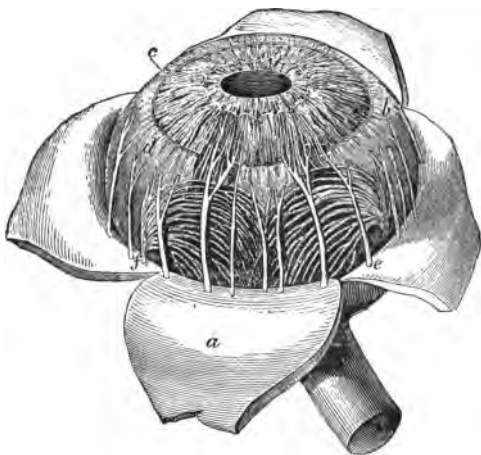


FIG. 168. —THE CHOROID COAT, *b*, AND IRIS, *c*, exposed by cutting and turning back of sclerotic and cornea; *e*, one of the nerves of iris; *f*, blood vessel.

of the large optic nerve. This nerve contains about five hundred thousand fibers, and enters at the back of the ball. The spot where it enters contains no nerve endings and is not sensitive to light. It is called the *blind spot*.

Experiment 43. In this experiment shut the right eye and be careful not to let the right eye move.

* Read this line slowly. Can you see the star all the time?

Within the coats of the ball, like the pulp within the rind of an orange, are the soft contents, divided into three

parts. The first is a watery liquid in front, which serves to keep the cornea bulged out (Fig. 167). It is called the *a'que-ous hu'mor*. The main cavity of the ball is occupied by a clear jellylike substance called the *vit're-ous humor*, which serves to keep the ball distended. Back of the iris, and separating the two humors just named, is the *crys'tal-line lens*, a beautiful clear lens, rounded out on both sides (convex). It serves to bring the light to a focus on the retina, thereby forming images of outside objects.

Muscles of the Eye. — It would be a great task to turn the head every time one desired to look at an object in another direction. There are *six pairs of muscles* that roll the eye around in its bed of fat to any desired direction (see Fig. 169).

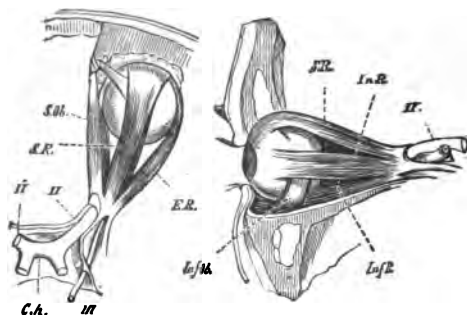


FIG. 169. — MUSCLES OF RIGHT EYEBALL (seen from above); MUSCLES OF LEFT EYEBALL (seen from the side).

C.A., junction and crossing of optic nerves; S.O.b., muscle that passes through a pulley.

They cause both eyes always to move together. The eye muscles are so important that *three of the twelve pairs of cranial nerves send fibers to these muscles*. These nerves and muscles play an im-

portant part in thinking. It is found, for instance, that we cannot distinctly imagine a herd of sheep jumping over a fence one after another, without slightly moving the eyeballs. Aided by these muscles, some pupils remember on which part of the page each topic in the lesson happens to be printed. This learning of accidental relations, instead of logical relations, prevents the mastery of a subject.

The eye, like a camera, has a dark lining (the choroid); the retina corresponds to the sensitive plate, and the lens brings the rays to a focus on it and forms the image.

The Path of Light in the Eye.—The light enters through the transparent cornea and passes through the aqueous

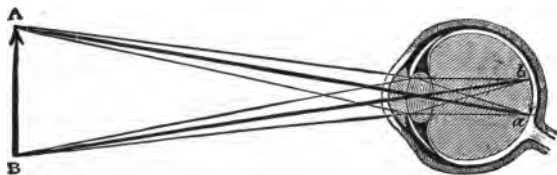


FIG. 170.—Image of object in eye is small and inverted.

humor. As it goes through the pupil, the iris shuts off all the light that is not needed. The crystalline lens receives the light that has been allowed to pass, and so bends the rays (Fig. 170) that by the time they have passed through the vitreous humor they fall upon the retina in just the right way to form a tiny image of anything outside.

The choroid absorbs any light that passes the retina. The iris and choroid of albinos have no pigment; hence they squint their eyes.



FIG. 171.—A coin in a basin of water shows how light rays may be bent by a lens.

Experiment 44. By holding your finger or a pencil in line with writing on the blackboard, you find that you cannot see both finger and blackboard distinctly at the same time—first one and then the other is distinct.



FIG. 172.—Change of lens in accommodation. (Jegi.)

Accommodation.—In order to focus the light upon the retina, the *lens must change*

shape for every change in the distance of the object looked at

(see Fig. 172). The shape of the lens can be readily changed, for it is elastic and has muscular fibers around its edges.

Experiment 45. For a few cents obtain from a jeweler a convex lens, or use a strong pair of spectacles worn by an old person. Hold the lens a few feet from a window (darken any other windows near).

A little beyond the lens hold a book, open at a blank page to catch the image. Have some one walk before the window.

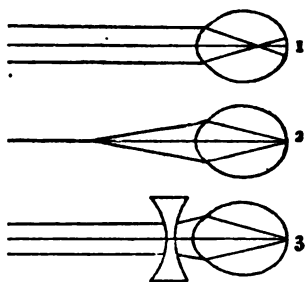


FIG. 173. — (1) NEARSIGHTED EYE (too long), which only focuses rays for near objects (2) unless concave glasses are used (3).

Defects in the Eye. — Some eyes are too long, and the lens brings the rays to a focus before they reach the retina. Such eyes are *nearsighted* (Fig. 173) and require glasses that round inward (concave). Some eyes are too flat, and the rays are

not brought to a focus soon enough. Such eyes are *farsighted* and require glasses that round outward (convex). See Fig. 174.

Care of the Eyes. — Because the eyes can do a large amount of work without giving pain, they are often abused. When reading or doing intricate work, turn the eyes from the work occasionally and look at some distant object; stop work before the eyes are tired. Twilight of early evening has ruined many good eyes.

You should always stop work before the twilight begins,

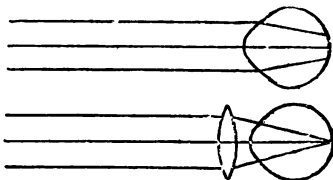


FIG. 174. — FARSIGHTED EYE (too short) which needs convex lens to focus rays upon retina.

for the light fades so gradually that you will surely be straining the eyes before you know it. Do not work with the light in front; the glare of the light makes objects appear dim. The light should come from above, and (for right-handed people) from the left. Do not read papers or books printed in fine type. We should not read when convalescing from illness; with the head bent down; when the eyes are sore; in jolting cars. Heating the eyes by a burner, or drying the eyeballs in a dry, stove-heated atmosphere, using a light without a shade, cause trouble with students' eyes. Of what are blood-shot eyes often a sign? The nutrition of the eye and the optic nerve is not so perfect in a person whose organs of digestion, respiration, and circulation have been injured by alcohol.

THOUGHT QUESTIONS. — **The Eye.** 1. The eye is shielded from blows by bony projections of —, —, and —. 2. The hairs of the eyebrows lie inclined towards —, in order to turn — from the —. 3. I find by trying it that I (can or cannot?) see the position of a window with my eyes closed. 4. The pupil appears to be black, because no — is — from the interior wall of the eye. I know that the iris is partly muscle, because it — the size of the —. 5. By holding my finger in line with writing on the blackboard, I find that I (can or cannot?) see both finger and writing distinctly at one time.

THE EAR AND HEARING

Sound. — Anything that is sending off sound does so by vibrating, or shaking to and fro, very rapidly. For instance, a vibrating violin string sets every particle of air near it swinging to and fro. The near particles strike the next ones and bounce back, these in turn strike against others, and thus vibrations called sound waves are sent through space in all directions from the sounding body. We feel these waves with the ear.

The ear consists of three portions, the *external* ear, the *middle* ear (or drum), and the *internal* ear (or labyrinth, see Fig. 175). The cranial nerve connecting the ear with the brain is called the *auditory* nerve. This nerve goes no farther than the internal ear; the outer and middle ear pass on the vibrations of air to the ends of the nerve fibers in the internal ear.

The **external ear** consists of a large wrinkled *cartilage* on the exterior of the head and a *canal* leading

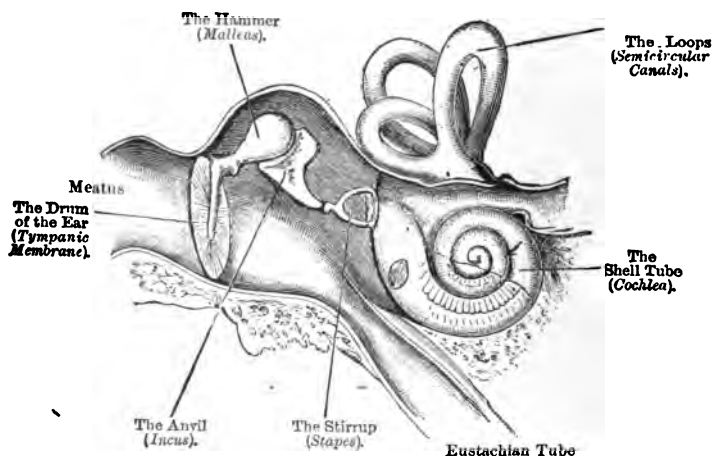


FIG. 175.—INTERNAL EAR (greatly enlarged).

from it, called the *meatus*. This passage is closed at its inner end by the drum membrane or *drum skin*. It is often called the drum, but this name is properly applied to the whole middle ear. If you look into the human ear, you cannot see the drum skin, even with the aid of a bright light, for the passage is slightly curved, as can be seen in Figure 175. Hence a missile or a flying insect cannot go straight against the ear drum. The skin lining this passage contains *wax glands*, which secrete

a bitter sticky wax, which helps to keep the passage flexible. This wax catches dust and usually stops insects that may enter. If an insect enters the ear, it may often be coaxed out by a bright light held close to the ear. The ear wax in a healthy ear dries with dust and scales of epidermis and falls out in flakes, thus cleansing the ear. It is unwise to probe into the ear with a hard object or even with the corner of a towel. It is not necessary to insert the finger in the meatus to cleanse it; it is one inch long, but only about one fourth inch across. (How large is the little finger?) Such meddling may do harm. *One of the chief advantages of the study of physiology is to warn us against ignorant meddling with the body*, whether by stimulating it, drugging it, deforming it, overheating it, half smothering it in close rooms, living contrary to our instincts, etc. A bean or pea is sometimes pushed into the ear by a thoughtless child. Pouring water into the ear will only cause the bean to swell. If the ear wax is deposited too fast, it will cause temporary deafness and earache. It may be syringed out with warm water. There should be no haste in removing a small object from the ear of a child unless a physician is present, as the harm is usually done by the attempts to remove it and not by the object. The cartilaginous ears on the sides of the head should be carefully washed because of their many crevices. Each ear has three muscles for moving it (see Plate III, Chart of the Muscles), but they have become so weakened by disuse as to be useless to most people.

The middle ear, or drum chamber, contains air (Fig. 175). It is separated from the outer ear by the drum membrane. It contains three bones (Fig. 175) which stretch across it and conduct the sound waves from the drum membrane to the inner ear. The handle of the first

bone, or *hammer*, is attached to the middle of the drum skin so as to be affected by the slightest quiver of the membrane. Its club-shaped large end rests upon the second bone, or *anvil*. A prong from the anvil presses upon the top of the *stirrup*, or third bone, which really has the exact form of a stirrup. The base of the stirrup presses upon the skin-covered oval window, which is in the wall of the inner ear. The middle ear is connected with the pharynx by a tube (the *Eustachian tube*; pronounced yoo-stake'e-an, see Fig. 175). This tube is opened every time we swallow. It allows the air from the throat to enter the middle ear and keep the air pressure equal on each side of the drum skin. This tube and the middle ear are lined with mucous membrane.

A cold in the head or a sore throat may extend through this tube to the middle ear and affect the hearing. This occurs because the tube is closed by congestion of its lining; the air of the middle ear may be partly absorbed, and the pressure of the outside air may cause the drum membrane to bulge inward, and to be stretched so tight that it cannot vibrate freely. Can you state the connections of the ear bones with each other and with the walls of the drum chamber?

Experiments.—46. Close the mouth and close the nostrils by pinching, and then swallow. This removes a little air from the pharynx, and the drum membrane is pushed in, causing a slight crackling sound. 47. Close the ears by pressing the palms against them. Can you hear anything? Is this effect the same when the ears are closed by pressing folded handkerchiefs against them?

The inner ear is called the *labyrinth*, because of its winding passages. There is a spiral passage called the

snail shell and three simpler passages called the *loops* (Fig. 199). The inner ear is filled with a limpid liquid, and when the stirrup vibrates against the oval window the liquid is shaken. This liquid conveys the vibrations to the *ends of the auditory nerve* found in the snail shell. Thus the sound waves reach the real end organs of hearing. There are six thousand rods connected with the ends of the fibers of the auditory nerve. It is believed that sounds of different pitch set different rods to vibrating. Thus the ear may be said to contain a wonderful harp of six thousand strings to aid us in perceiving sounds of every pitch. Sound waves can also reach the labyrinth through the bones of the head.

Experiment 48. Hold a watch between the lips and notice its ticking. Close the teeth down upon it and notice any change in the sound. Cover one, then both, ears, and note the result.

Sense of Equilibrium.—Some fibers of the auditory nerve end in the loops and are not believed to be used in hearing. It is believed that each loop acts like a carpenter's level, and the varying pressure of the fluid upon the nerves in the loops tells us the position of the body and constitutes the sense of equilibrium.

Experiment 49. If the body is whirled around for a little while, the unaccustomed pressure of the fluid on the loops confuses the sense of equilibrium, and dizziness results.

How do we know the direction from which sound comes? The external projections that we call ears are of little importance in hearing; yet they enable us to hear sounds a little better from the front than from behind. *A sound coming to the ears from the side is louder to the ear on that side.* This enables us to judge the direction of its source.

Experiment 50. Let the class stand in a circle. Blindfold some one and place him in the middle of the circle. Pass a bell around the circle and let it be tapped at intervals. Can the blindfolded one point in the direction whence the sound comes? Why does he confuse the direction of sounds coming directly from the front and rear?

Impaired hearing and deafness may be caused by disease of the auditory nerve, labyrinth, middle ear, rupture of drum head, stoppage of the passage of the outer ear, or by inflammation of the lining of the Eustachian tube. If either the auditory nerve or labyrinth is diseased, the deafness may be incurable. Earaches are caused by sores or inflammation of the outer or middle ear. They may sometimes be relieved by applying to the ear, cloths wrung out of very hot water. Water sometimes gets into the ear while bathing. It may be removed by shaking the head while it is held to one side. Putting cotton into the ears, or wearing mufflers over them, or wearing the hair combed over them, makes the ears tender by overheating them. Inflammation or sores sometimes make holes through the drum membrane and impair the hearing. The hair around the ears should not be left wet. Scarlet fever, mumps, catarrh, a clap with the hand upon the ear, quinine and other drugs, may cause impaired hearing or deafness. To cure a catarrh often restores the hearing.¹ Pupils with weak hearing should be given front seats. Dullness and inattention in school are often to be accounted for by partial deafness.

¹ Catarrh is often caused by overeating. A certain actor with catarrh went to a noted New York physician who said: "I can do nothing for you. You need a new mucous membrane for your nose. I cannot make mucous membranes." Yet in two years the actor was well: for he learned to eat moderately and ate simple, nourishing foods (chiefly raisins, nuts, fresh fruit, dried figs, and dates) and his cells made him a new mucous membrane.

Experiment 51. Blindfold one of the class; cover one ear and hold a ticking watch near the other ear. Carry it away slowly, and find out how far it can be heard. Test the other ear in the same way, and measure the distance for each ear. Are the ears of the pupil equally sensitive?

THE VOICE

The voice is produced in the **larynx**, a cartilaginous box at the top of the windpipe. The larynx is felt in the neck as the Adam's apple. During the act of swallowing, it is closed by a trap door of cartilage, called the *epiglottis*. It is lined with mucous membrane. This lining is folded in from each side so that the folds nearly meet in the middle. The narrow slit between the folds is called the *glottis*. The liplike folds are inappropriately called the *vocal chords*. The folds enclose many fibers of elastic tissue; thus the vocal chords consist of mucous membrane and elastic tissue. Usually, the breath passes the vocal chords without setting them in vibration (Fig. 176). By the muscles of the larynx moving the cartilages forming the larynx, the vocal chords are stretched tight and their edges brought close together; then the breath cannot be sent out without producing sounds called the *voice*.

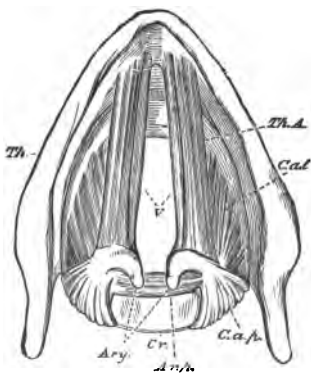


FIG. 176. — THE VOCAL CHORDS and the cartilages to which they are attached. Mucous membrane removed.

Pitch and Loudness of Voice. — The more forcibly the breath is sent out, *the stronger the vibrations of the chord* and the *louder* the voice. The tighter the chords are

stretched, *the faster they vibrate, the shriller the voice*, just as the tighter the strings of a violin are stretched, the higher the note. The heavier strings on the violin produce the lower notes. If the vocal chords are heavy with blood, as during a cold, a hoarse, low voice results. The longer strings on a harp produce the lower notes. When a boy reaches about sixteen years of age, the larynx enlarges, the vocal chords lengthen, and his voice changes and becomes lower in pitch. Because of the greater length of chords, the voice of a man is about an octave lower than the voice of a woman.

Quality of Voice. — Another important property of the voice is quality. This depends upon *the shape of the cavities of the throat, nose, and mouth*. Two persons may sing or speak in the same key and with the same loudness, but the voices are not alike, for the echoing chambers just named give the two voices different quality. The loss of only one tooth may affect the quality of the voice.

Experiment 52. Let a pupil go to the back of the room and read a paragraph, and hold his nose until partly through the reading. Or the teacher may read with his face and hand hidden by a large book. Let the pupils raise their hands when they notice a change in the quality of the reader's voice. Does the experiment show that a "nasal" tone comes partly through the nose or through the mouth only?

Care of the Voice. — The delicate mucous membrane of the air passages is irritated and inflamed by smoke, dust, alcoholic drinks, condiments, or exposure. Sir Morell Mackenzie, M.D., says: "The hoarse tones of the chronic drinker are due to chronic inflammation of the mucous lining of the larynx. The originally smooth surface being roughened and thickened by the irritation of alcohol, the vocal chords have less freedom of movement, and their vibrations

are muffled by the unevenness of their edges." Good habits of breathing are the best foundation for a good voice. One must breathe naturally and hold the head erect in order to have good control of the voice. Singing is one of the best means of cultivating the voice. One should not sing when suffering from a cold, nor so long as to tire the vocal chords. A youth should not sing during the years when the voice is changing. Attempting to sing notes of a pitch hardly within the range of the voice may strain the vocal chords.

REVIEW QUESTIONS. — **Chapter VIII.** 1. Describe an act requiring the harmonious action of a number of organs. 2. Show that we need nerve centers as well as nerves. 3. What is the unit of nerve structure? 4. Name the parts of a neuron. 5. What are nerve fibers; dendrites; axons; nerves? 6. What are the parts of a gray fiber? Which parts are lacking in a white fiber? What is white matter; gray matter? 7. Into what two classes according to function are cells and fibers divided? 8. What is a ganglion; a nerve center? 9. Describe the structure and work of the spinal cord. 10. Trace the nerve impulse in a reflex act from the skin to the muscle. 11. How are reflex acts related to consciousness and the will? 12. What is the effect of removing the brain from lower animals? 13. What are the three chief parts of the brain? 14. Where is the medulla? What centers are located in it? 15. How does the condition of the blood regulate the breathing? 16. Describe the structure and function of the cerebellum. 17. Describe the structure of the cerebrum. 18. How many pairs of spinal nerves; cranial nerves? 19. What are the functions of the cerebrum? 20. Locate several cerebral sensory centers; motor centers. 21. To what extent does the cerebrum control the lower nerve centers? Why is it well that this control has a limit? 22. When does the sympathetic system send messages to the cerebrum? 23. Through what do the sympathetic fibers pass after leaving the spinal cord? 24. What is a plexus? 25. Why is the sympathetic system so named? 26. State five differences between the sympathetic and cerebro-spinal nerves. Do the two kinds of nerves form two distinct systems? 27. Show how the sympathetic nerves control the digestion of food; the size of the blood vessels; the heat of the body. 28. Show how the mind and viscera sometimes affect each other.

1. What supplies energy to the nervous system? 2. Compare the state of the body during sleep and waking hours. 3. Repeat the suggestions concerning sleep. 4. What is the best way to prepare for a severe mental effort? 5. Why does change of occupation rest us? Will it always rest us? 6. Upon what fact does the formation of habits depend? 7. What changes take place in the nerve cells as an old habit is broken? What habits are hardest to break? 8. Show the importance of forming good habits. 9. Distinguish between healthy fatigue and fatigue caused by sluggish habits. 10. What is the general meaning of pain? What are four causes of pain? 11. Discuss headaches resulting from excessive blood pressure; imperfect nutrition; from poisons and impure blood. 12. How do headaches often turn out to be a source of injury instead of a benefit? What may be done with benefit at the first sign of a sick headache? 13. Through what system do drugs generally act upon the body? 14. What are the signs of nervousness? What are the causes of nervousness among city children? 15. How does indoor life and the study of books sometimes prevent sound development of children? 16. Name six ways in which the health of school children may be cared for.

REVIEW QUESTIONS. — **Chapter IX.** 1. What sense should be numbered with the special senses? 2. State several differences between special and general sensation. 3. Name six general sensations. What kind of general sensation can be brought by any nerve? 4. Give a reason for heeding each of these general sensations: pain; sleepiness; thirst; hunger; fatigue. State ways in which each are disregarded. 5. Describe the end organs of the sense of touch. 6. To what two things does the expression "delicacy of touch" refer? 7. Where can we tell the point touched with the greatest exactness? 8. Give facts to show that the temperature sense is easily fatigued. 9. What parts of the skin are especially sensitive to heat? 10. What two kinds of nerves give us the muscular sense? 11. Which sense keeps us conscious of the position of the limbs? 12. What are the three kinds of papillæ in the tongue? Which kinds give us the sensation of taste? 13. What are the three principal tastes? 14. Where do the fibers of the nerves of smell end? Do we smell solids, liquids, or gases? 15. What are flavors? 16. What is said of the value of taste and smell as guides? 17. What is a common cause of the sense of smell becoming weakened? Why do some cooks put strong seasoning in food? 18. State several evils of high seasoning in food. 19. State the various ways of entrapping the sense of taste in order to use the different narcotics. What is the effect of narcotics upon the senses of smell and taste? 20. What is the connection between pleasant taste and digestion?

1. Through what substance does light travel to the eye? 2. What is the orbit, and how is the eye placed in it? 3. Why do some people appear to have large eyes? What enables the eye to change expression? 4. State the uses of the eyelids, lashes, and brows. 5. How are the tears formed and conducted away? What is their use? 6. Describe the three coats in the wall of the eyeball and the three parts of its contents. 7. What is the use of the muscles of the eye?

1. What are the three divisions of the ear? 2. Name the parts of the external ear. How is it taken care of? 3. Describe the middle ear and the three ear bones. What is the use of the Eustachian tube? 4. Describe the inner ear. 5. What gives the sense of equilibrium? 6. How do we know the direction from which sound comes? 7. What are the causes of impaired hearing? 8. What is the larynx; epiglottis; vocal chords; glottis? 9. What causes the voice to vary in loudness; pitch; quality? 10. What is stated concerning the care of the voice?

GENERAL REVIEW (*Questions from State Examinations*).—What and where are these: portal vein; diaphragm; vertebra; aorta? Name five glands; five secretions; five tissues. State functions of each. What arteries carry venous blood? What membrane is chiefly affected in catarrh; peritonitis (Fig. 134); pleurisy; bronchitis? How does alcohol cause the face to flush? Draw a diagram of the alimentary canal (Fig. 120), writing the names of these parts in their proper places: esophagus; stomach; pylorus; duodenum; colon; rectum. Of what tissue do each of these consist: outside of stomach (Fig. 73); inside of stomach; mass of tongue; tendons? What is the function of: aorta; lacteals; portal vein; ligament? By what system is the body put into relation with the outside world; its nutriment prepared; distributed? How is heat generated in the body? How does alcohol injure the lungs? Name the processes by which food is converted into tissues by the body (p. 150). How can you show that the breath contains water; carbon dioxide gas? (p. 113.) Bile is secreted from what, by what, and for what purposes? State three losses that the body is constantly sustaining. Mention the subdivisions of the brain and describe each as to (1) size; (2) form; (3) matter; (4) position; (5) function. Suppose a blood cell in the inferior vena cava; trace its route into the aorta. State what you have observed of the effects of alcohol upon a healthy body. When, if ever, should alcohol be used? (p. 220.) Locate the appendix (Fig. 133). Distinguish between organic and inorganic foods, and give examples. What means has the body for combating disease germs? State the effects of muscular exercise upon six of the principal organs. Draw a diagram showing the correct way of ventilating a room heated by a stove (Fig. 105). State the effects of hasty eating.

NOTE ON INJURIES.—For treatment of *dislocations*, see page 60; *fainting*, see page 86; *cut blood vessels*, page 92; for *asphyxia* and other accidents, see Figs. 177 to 182.



FIG. 177.—RESUSCITATION, *Inspiration*, by drawing the arms over the head.



FIG. 178.—RESUSCITATION, *Expiration*, by pressing arms on sides and chest.

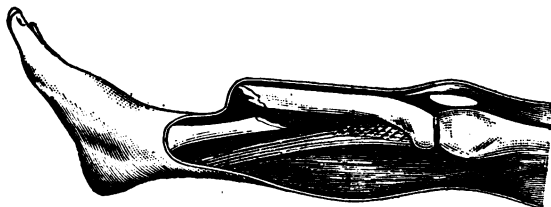


FIG. 179.—A BROKEN SHIN. To keep bone from cutting flesh and skin, never move the person until a temporary splint has been provided by tying walking canes or umbrellas around the limb with handkerchiefs.



FIG. 180.—SLING for broken arm.



FIG. 181.—KNOT TWISTED ON ARTERY above the cut.



FIG. 182.—TOE DISTORTED BY TIGHT SHOE.

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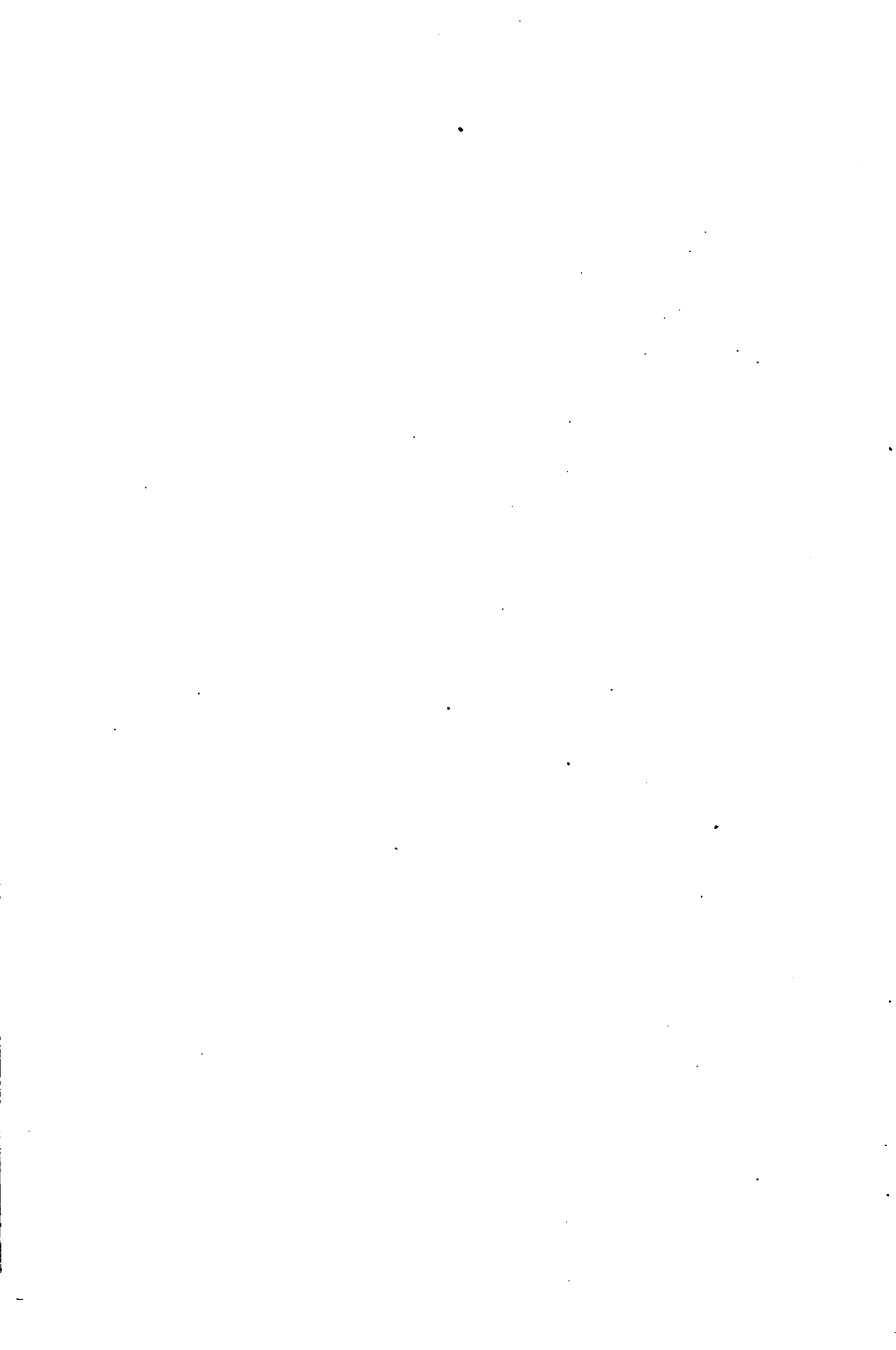
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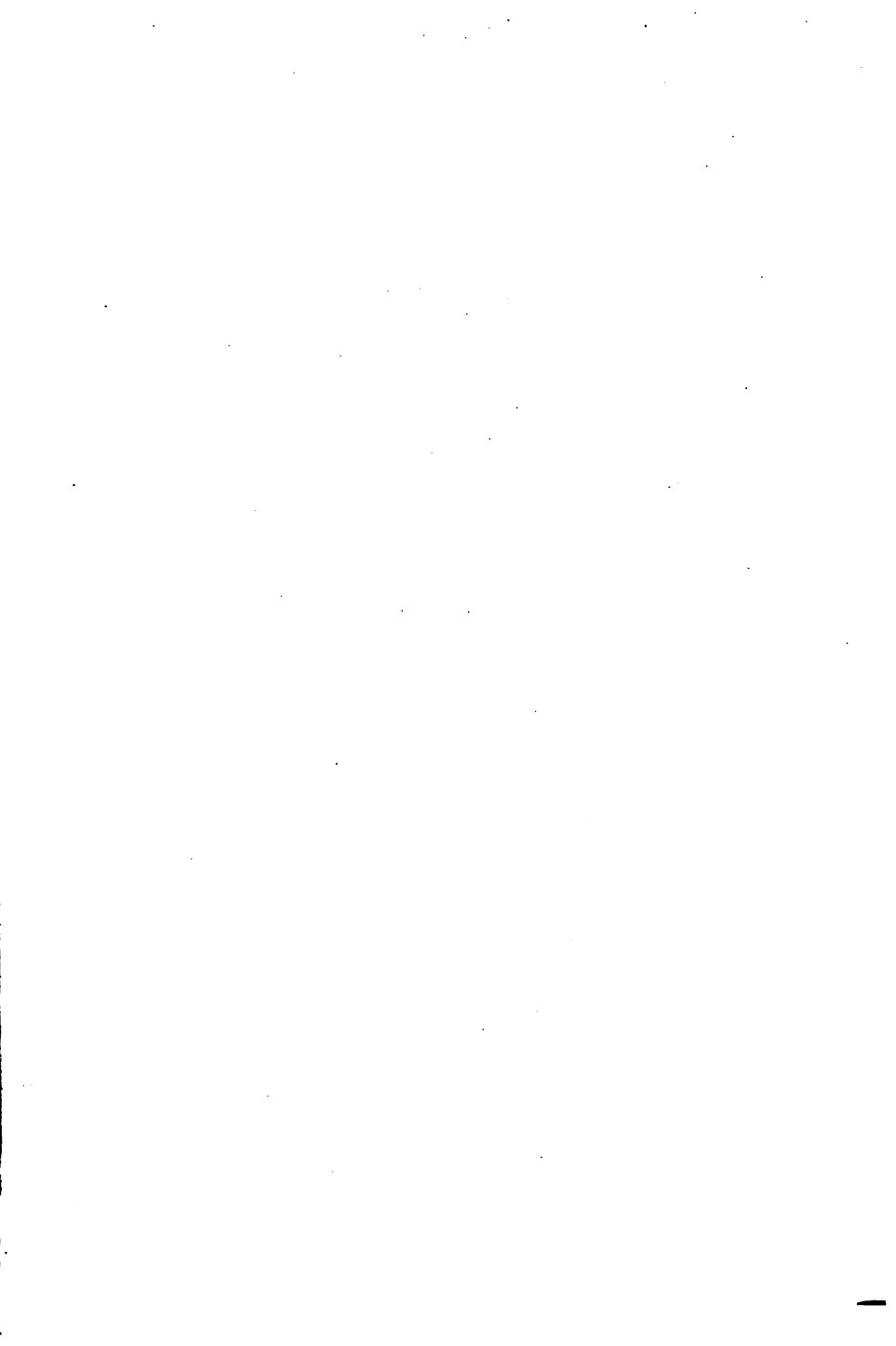
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